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## • • FAMOUS VICTIMS OF WATER BORNE DISEASES



### LOST TO A GREAT CAUSE... LOUIS IX, *Crusader*

\*James A. Tobey, Dr. P. H.  
Water Works Eng. Vol. 87-7

WHEN Louis IX—King of France—sailed on his Second Crusade, no one had even dreamed of CHLORINATION, the universal protection of drinking water. Had it then been known perhaps his army would have reached the Holy Land,—instead of of experiencing that sorry plight at Tunis sixty days later when more than half were dead and dying from sickness and Louis himself succumbed to dysentery—a water-borne disease.

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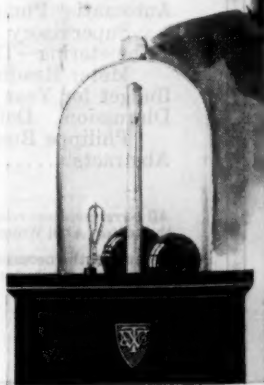
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# JOURNAL

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### AMERICAN WATER WORKS ASSOCIATION

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*Discussion of all papers is invited*

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#### PIPE CORROSION EXPERIMENTS, CATSKILL SUPPLY, NEW YORK CITY

BY FRANK E. HALE

*(Director of Laboratories, Department of Water Supply,  
New York, N. Y.)*

The corrosion problem has several aspects, which may be classified, as follows:

1. Prevention or reduction of red water.
2. Reduction of corrosion of the metal.
3. Leakage due to pitting and eating away of metal.
4. Clogging of pipes in buildings, and reduction in carrying capacity of mains.

Prior to the present experiments, the entire Catskill supply was treated for six months with soda ash, 0.5 grain per gallon, sufficient to remove all free carbonic acid, to increase average alkalinity from 8 to 15 p.p.m., 2 p.p.m. of which was neutral carbonate, and to cause average pH of 8.5. Red water was prevented and soon noted by many. Three buildings were chosen in different parts of the City, one two-years and the other about fifteen-years old, the former having galvanized steel and one of the latter galvanized wrought iron. For six months prior to treatment and during the six months treatment weekly samples of the cold supply to the buildings and of the hot and cold supplies after exposure to several floors of piping in the buildings were analyzed on the spot. There was no certain evidence

of reduction of corrosion as shown by oxygen consumed with possible exception of the cold galvanized pipe of the two-year old building. Details of the above cannot be included in the present paper. As consumption of water in these buildings could not be controlled, Chief Engineer Brush requested that the experiments to be described be carried out at the Ashokan Laboratory.

#### EXPERIMENTAL PLANT AND METHODS

Seven cypress tanks, 1,000 gallons capacity each, were erected with proper supports on the roof of the mazzanine floor on which the laboratory is situated. The pipes lead along the roof, down the end to the main floor below the laboratory, and then back to a point nearly below the tanks. On the lower floor connections were made which rise and pass through an enclosed tank of water heated by electricity and suspended below the floor of the laboratory. These hot pipes were then brought down again to the main floor level. The electric heaters are automatically controlled and temperature set at 150° to 160°F. Discharge, hot and cold, is through faucets to waste troughs and the hot pipes pass through cooling-pipe condensers used during sampling. Flow is maintained by copper discs through which a tiny hole has been drilled and held in place by hosebib connections fitted with washers. The pipes are  $\frac{3}{4}$ -inch diameter. (See figure 1.)

The purpose of the experiments was to determine whether treatment of the Catskill supply to any reasonable extent could be made which would reduce corrosion to an appreciable amount, at a reasonable cost, and what effect such treatment would have upon pipes of such material as were commonly used. It was desired that piping already installed be not injured by any treatment that might be adopted. The first series of experiments lasted two years. The tanks were filled with water as follows:

No. 1—Raw water

No. 2— 5 p.p.m. silica treatment (17 p.p.m. sodium silicate as furnished)

No. 3—10 p.p.m. silica treatment (34 p.p.m. sodium silicate as furnished)

No. 4— 5 p.p.m. soda ash treatment

No. 5—10 p.p.m. soda ash treatment

No. 6— 4.5 p.p.m. lime hydrate treatment

No. 7— 4 p.p.m. sodium hydrate treatment

Catskill water averages 3 p.p.m. free carbonic acid ( $\text{CO}_2$ ) and 8 p.p.m. alkalinity with usually a resulting acid pH. The treatments

with 10 p.p.m. sodium silicate, 10 p.p.m. soda ash, lime hydrate, and sodium hydrate were designed to be of practically equal power in neutralizing the free carbonic acid to bicarbonate and was sufficient

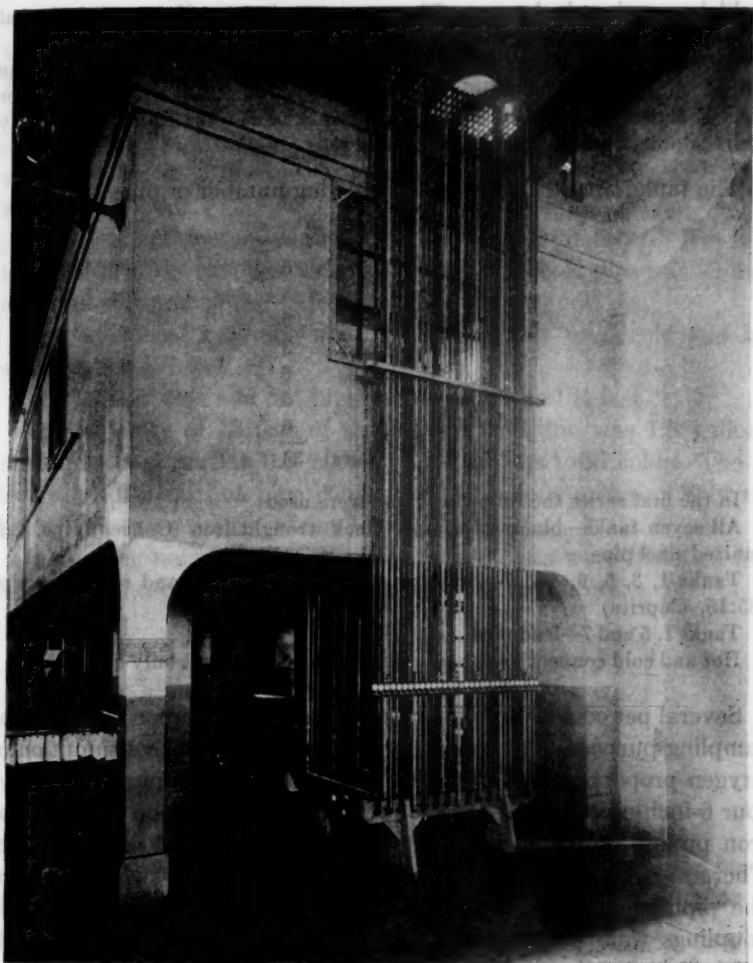


FIG. 1. EXPERIMENTAL SET-UP

to care for slightly more than the average free carbonic acid. It was not practical to change the dose each day for varying carbonic acid. The reduction of liquid in each tank was measured each day, made

up to full quantity, required addition of chemical added, and churned by an electric stirrer. The chemicals were specified as follows:

Hydrated lime for use in water treatment, containing not less than 90 percent available calcium hydroxide ( $\text{CaO}_2\text{H}_2$ ), 50 pound bag.

Flake caustic soda, known as 76 percent actual test sodium oxide. It shall contain not less than 98 percent sodium hydroxide ( $\text{NaOH}$ ), 50 pound drum.

Sodium silicate, brand "N," 41° Bé, syrup form, containing a ratio of sodium oxide to silica 1:3.25, containing approximately 29 percent silica and 8.9 percent sodium oxide, manufactured by the Philadelphia Quartz Company Philadelphia, Pa., 100 pounds, in 5-pound cans.

The tanks were drilled for the following number of pipes:

<i>Tank Number</i>	<i>Number of pipes</i>
1	6
2	3
3	5
4	3
5	6
6	5
7	6
Total	34

In the first series the following pipes were used:

All seven tanks—black steel pipe, black wrought iron (Cohoes) pipe, galvanized steel pipe.

Tanks 1, 3, 5, 6, and 7—brass pipe (60:40, Plumrite) and red brass pipe (85:15, Cuprite).

Tanks 1, 5 and 7—lead pipe.

Hot and cold connections on all pipes but lead, cold test only on lead

Several pet cocks were placed at different points upon the pipes for sampling purposes, but were only used once to show consumption of oxygen proportionate to distance travelled in the piping. Twenty-four 6-inch nipples joined by couplings were inserted on each kind of iron piping, both hot and cold, and 6 on each kind of brass pipe. There were no nipples on the lead pipes. The nipples were cut from the piping in order to prevent differences of composition, though couplings were purchased. All piping was purchased in the open market, hence the first wrought iron happened to be Cohoes. The nipples were weighed before installation on an analytical balance, about 225 to 300 grams each, and no dope was used in the joints. This resulted in considerable leakage so that nipples removed later on for weighing were chosen with consideration for absence of outside corrosion.

During the first nine months the hot pipes were allowed to drip

(fast drops) on white tiles to ascertain presence or prevention of red stains. The rate varied, but was approximately one gallon per hour for each pipe. The cold pipes ran a thin stream, about four gallons per hour. Regulation was by copper discs with tiny holes as previously mentioned. After nine months both hot and cold were run at a thin stream at rate of  $2\frac{1}{2}$  gallons per hour plus or minus 10 percent. In order to approach household use, once a day each pipe was flushed with faucet wide open so as to fill a 3-gallon pail. General appearance of the water, turbidity, color, etc., was noted and recorded. This was sufficient to more than empty each pipe and replace with fresh water from tank.

The common portion of each pipe was approximately 78 feet long to junction of the hot take-off. The additional cold pipe was 30 feet, making total cold pipe 108 feet.

The additional hot pipe was 53 feet, making total cold and hot combination 131 feet.

The total of cold and hot pipes in one line was 161 feet.

The capacity of 78 feet of the common portion was 1.8 gallons, remaining cold portion 0.7 gallon, or 2.5 gallons total cold. The 53 feet of additional hot pipe contained 1.2 gallons and probably the actual hot water portion about 1 gallon.

In the beginning (first few tests) before discs were installed and drip was hand-controlled contacts were about as follows:

Contact, hours	Location
0.9	Common portion of pipe
0.7	Additional cold portion
1.6	Total cold pipe
1.2	Additional hot pipe
0.9	Common portion
2.1	Total hot pipe

With the discs installed on the cold pipes (4 gallons per hour) during the remainder of first nine months and drip on hot pipe (1 gallon per hour) contact was as follows:

Contact, hours	Location
0.36	Common portion
0.14	Additional cold pipe
0.50	Total cold pipe
1.2	Additional hot portion
0.36	Common portion
1.56	Total hot pipe

After the  $2\frac{1}{2}$ -gallon rate of flow was established on cold and hot pipe, remainder of period, the contact was as follows:

Contact, hours	Location
0.36	Common portion
0.28	Additional cold portion
0.64	Total cold pipe
0.36	Common portion
0.48	Additional hot portion
0.84	Total hot pipe

The tank solutions were tested each day to see that they were correctly made up. When first started a full set of determinations was made and repeated two days later. Tests were then on a weekly basis for several months and then twice monthly. After the start the work has been carried on by one chemist with laboring assistance. Consequently as there were 65 pipes to test work was carefully scheduled as follows:

- First day of week, pipes of tank 1
- Second day of week, pipes of tank 2 and 3
- Third day of week, pipes of tank 5
- Fourth day of week, pipes of tank 4 and 6
- Fifth day of week, pipes of tank 7

First, samples for oxygen determination were quietly drawn by screwing on an attachment with rubber tubing and running water to the bottom of 250-cc. glass-stoppered bottles and overflowing. Next quart samples were taken by the overflow method and the following determinations made in order: Free  $\text{CO}_2$ , pH, iron, alkalinity to phenolphthalein and to methyl orange, turbidity, and color.

Every six months a pair of iron-pipe nipples (steel, wrought-iron, and galvanized-steel) was removed, one chosen to be cleaned and weighed to determine loss, and one preserved and photographed with light shining through it to show tuberculation and clogging. Cleaning was by a wire brush, similar to a small boiler tube cleaner, drawn 15 times back and forth through the nipple held under water, nipple rinsed in water, then alcohol, then gasoline, dried in hot air oven, air cooled and weighed. Blanks were similarly treated and loss correction applied. A single brass and red brass nipple was removed each time for photographing, cleaning and weighing. These, however, were brushed 10 times. The location of the hot nipples thus removed was just after the heater and of the cold in a corresponding

location. At the end all nipples of the iron pipes were removed and weighed. The nipples were grouped in the locations shown on figure 2. The steel, wrought-iron, and galvanized nipples of the final group were also split lengthwise and photographed both clean and tuberculated, and the 5 deepest pits were measured with a  $\frac{3}{8}$ -inch bearing gauge.

Every six months total clogging was measured by drawing a 3-gallon pail of water with faucet wide open and recording the seconds required to fill.

In order to sample the tank waters properly taps were placed near the tanks between tank and shut-off valve. On tanks 1, 3, 5, 6 and 7 they were placed on the red brass pipe, and on tanks 2 and 4 on the galvanized pipe as there were no brass lines.

In order to prevent confusion and to simplify records the pipes were numbered on a system of three units, first place representing the tank, second place the kind of pipe, and third place whether cold or hot. For the first series of tests the system was as follows:

	RAW	5 P.P.M. SiO <sub>2</sub>	10 P.P.M. SiO <sub>2</sub>	5 P.P.M. SODA	10 P.P.M. SODA	4.5 P.P.M. Ca (OH) <sub>2</sub>	4 P.P.M. NaOH
	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7
Steel, cold.....	111	211	311	411	511	611	711
Steel, hot.....	112	212	312	412	512	612	712
Wrought Iron, cold.....	121	221	321	421	521	621	721
Wrought Iron, hot.....	122	222	322	422	522	622	722
Galvanized Steel, cold.....	131	231	331	431	531	631	731
Galvanized Steel, hot.....	132	232	332	432	532	632	732
Brass, cold.....	141		341		541	641	741
Brass, hot.....	142		342		542	642	742
Red Brass, cold.....	151		351		551	651	751
Red Brass, hot.....	152		352		552	652	752
Lead, cold.....	161				561		761

To designate the nipples the letters of the alphabet were used together with the pipe number thus 111-A, 111-B, etc. A filing card

system was used for recording the weights and data regarding the nipples.

When nipples were removed they were replaced by special enamel-lined nipples so as not to change length of pipes nor introduce fresh metal surface.

On account of rather extraordinary results in the first series, a second series was started for a further period of two years. The rate of flow was  $2\frac{1}{2}$  gallons per hour on all pipes, cold and hot, except for a

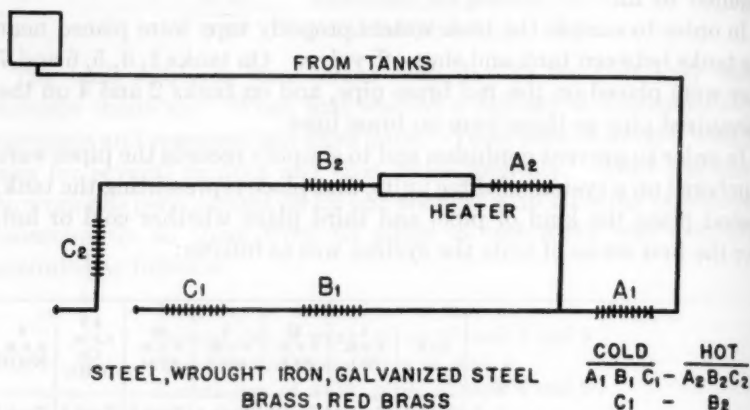


FIG. 2. DIAGRAMMATIC SKETCH SHOWING LOCATION OF NIPPLES

short period of hot water drip to record effect on white enamel-tiles. The new pipes were numbered as follows:

	Number
Byers wrought-iron.....	7
Reading wrought-iron.....	8
Galvanized wrought-iron.....	9
Copper tubing.....	X
Cement-lined steel.....	Y

This piping was also purchased in the open market. The cement-lined steel was manufactured by the National Tube Company, and fittings were also cement-lined. In this series only 12 nipples for each iron pipe were used and for cement-lined steel, and 8 nipples of copper pipe, the fittings of which were heavy and cumbersome. The special sampling cocks along the lines were omitted. In putting the pipes together no dope was used, but caulking yarn made a tighter job than in the first series. The cement-lined pipe was tested only cold. In rearrangement some of the brass and red brass pipes were

continued for the complete four years, as, for example, the brass pipes on tanks 1, 3 and 5 and red brass on tanks 1 and 7. Byers wrought-iron replaced the steel, Reading wrought-iron replaced the Cohoes wrought-iron, and galvanized wrought-iron the galvanized steel. An additional line of copper was added to tank 1 and took the place of red brass on tanks 3, 5 and 6 and of brass on tank 7. Tank solutions remained the same as in the first series. The system of designation follows:

	RAW	5 P.P.M. SiO <sub>2</sub>	10 P.P.M. SiO <sub>2</sub>	5 P.P.M. SODA	10 P.P.M. SODA	4.5 P.P.M. Ca (OH) <sub>2</sub>	4 P.P.M. NaOH
	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7
Byers W. I., cold . . . . .	171	271	371	471	571	671	771
Byers, W. I., hot . . . . .	172	272	372	472	572	672	772
Reading W. I., cold . . . . .	181	281	381	481	581	681	781
Reading, W. I., hot . . . . .	182	282	382	482	582	682	782
Galv. W. I., cold . . . . .	191	291	391	491	591	691	791
Galv. W. I., hot . . . . .	192	292	392	492	592	692	792
Brass, cold . . . . .	141		341		541		
Brass, hot . . . . .	142		342		542		
Red Brass, cold . . . . .	151						751
Red Brass, hot . . . . .	152						752
Copper, cold . . . . .	1X1		3X1		5X1	6X1	7X1
Copper, hot . . . . .	1X2		3X2		5X2	6X2	7X2
Cement-lined Steel, cold . . . .	1Y1				5Y1		7Y1

A similar scheme of tests was carried out as in the first series. Pairs of iron nipples were removed every six months, one preserved and the other cleaned and weighed. At certain of the intervals photographs were taken. The brass, red brass, copper and cement-lined nipples were removed at yearly intervals. The copper nipples were weighed with the fittings. They were cleaned by a test tube brush under water, soaked several minutes in dilute ammonia in an agate pan (1 part commercial ammonia to 3 parts water), then brushed in the ammonia, then in water, then dipped in alcohol, in

gasoline, and dried. The ammonia turned blue, generally cleaning off the oxide film and leaving a bright copper surface. Flow tests were made as in the first series.

#### RESULTS

The general averages for the first series, cold and hot, for the various determinations, divided into two periods corresponding to the different rates of flow, are shown in table 1. Similar general averages for the second series, but for the full period, as there was only one rate of flow, are contained in table 2.

The first point noted was in the drip tests for stain with hot water on white tiles. Where the free carbonic acid was neutralized rust stains were prevented for two days. In common use in buildings this period is generally sufficient to prevent red water. If the building is left vacant as during vacation or the water allowed to stand in the pipes, red water will occur temporarily in the first water drawn. As it is carbonic acid that carries soluble iron to the tap in the form of ferrous bicarbonate and as ferrous carbonate neutral is very insoluble, the neutralization of the free carbonic acid by any alkali lessens red water. However, some of the alkaline treatments appeared to carry iron to the tap in colloidal solution or suspension to the extent that it will even pass through a filter paper. Particularly noticeable is this phenomenon with soda ash or caustic soda. (It has also been noted by us in treatment of iron-bearing well waters when planning iron removal plants. Similarly silicic acid, present in high ratio silica to sodium oxide sodium silicate, has held as much as 2 p.p.m. iron in colloidal solution for two months with absolutely no deposition of ferric oxide even though the color indicated ferric condition.) Stains were produced in every case with steel or iron pipes, although not as dense or adherent with the treated waters as with the raw.

The second conclusion noted, and this is very important, was that none of the treatments reduced the oxygen consumed in the *cold action* on black steel, black wrought-iron, galvanized-steel, galvanized wrought-iron, cement-lined steel, lead, brass, red brass, or copper to any appreciable extent and, in general, the figures were somewhat higher than with the raw water in steel and wrought-iron pipes. This agrees with the fact previously known that ferrous iron will oxidize to ferric iron more readily in slightly alkaline solution. This was shown in our own experiments back in 1912 and has also been noted and published by Cushman and Gardner. Table 3 appended

shows the oxygen consumed figures as averaged for the different treatments cold and hot and for the different pipe materials.

The third point noted was that in the hot action the only treatment that lowered the oxygen consumed with any consistency with steel, wrought-iron, galvanized-steel or galvanized-iron was the sodium silicate treatments,—with black steel or iron amounting to about 10 percent and with galvanized pipe 10 to 45 percent, averaging 28 percent. That this action is due to combination of silica with the zinc in the galvanized pipe has been shown by finding silica by analysis in the protected film, and with iron it probably builds up in the rust tubercles. That it is not due to the action of the alkali is shown by the fact that the other alkaline treatments failed to show any such action. The action on brass, red brass, copper, and lead shows such minor amounts of oxygen consumption that differences are hardly reliable. However, it may be said that treatment with alkaline waters did not increase oxygen consumption as might have happened since zinc and lead in particular are subject to solvency in strong alkalies. With galvanized-steel and galvanized-iron, however, the hot nipples apparently did lose more weight with the higher alkaline treatments.

In the fourth place the above statements as to extent of corrosion as indicated by oxygen consumption are also corroborated by the loss of weight shown by the 6-inch nipples (table 4.) It will be noted that the lower losses in weight with black steel or black iron pipe cold were generally with untreated raw water. With the hot pipes throughout the lowest losses were consistently with the silicate treated waters.

That prevention of corrosion is not a concurrent result with prevention of red water, as indicated above, is also proven by the accompanying photographs taken with a view through the nipples. Although the dissolved iron may not be carried through to the tap to cause red water when the carbonic acid is neutralized, it is oxidized to rust and built up into tuberculation just that much faster. The worst nipples in the lot are the hot black wrought-iron nipples where the water was treated with sodium silicate. Hence on old piping from which the galvanizing is gone by years of service, treatment with silicate while slowing up corrosion somewhat in the hot lines does so largely by building up incrustation and reducing available flow.

To show this clogging in another way and in a manner to get the effect throughout the pipes, flow measurements were made as previ-



<i>Wrought Iron</i> ( <i>Cohoes</i> )													
121	6.5	7.9	2.0	2.1	6.8	6.9	1.40	0.40	8	8		6	4
221	6.2	7.5	0.9	0.8	7.2	7.6	1.55	0.60	10	11		5	4
321	6.1	7.4			8.0	8.5	1.20	0.40	12	13	1	4	4
421	6.3	7.3	1.3	1.0	7.3	7.5	1.95	0.65	12	13		6	4
521	6.4	7.4			8.0	8.5	1.65	1.60	15	17	1	4	5
621	6.5	7.2			8.2	8.5	1.85	0.85	12	13	2	4	4
721	5.9	7.0			8.1	8.5	1.60	1.30	12	13	2	4	5
Average.....													
3.4													
<i>Galvanized Steel</i>													
131	7.8	10.2	1.0	2.1	7.2	6.9	0.10	0.10	9	9		3	4
231	8.1	10.4	0.0	1.2	7.6	7.4	0.05	0.10	11	11		4	4
331	7.8	10.4			8.3	8.4	0.05	0.10	13	13	2	3	4
431	7.8	9.8	0.3	1.2	7.7	7.4	0.10	0.10	13	13		3	4
531	8.0	10.5			8.4	8.5	0.10	0.10	17	17	3	4	4
631	7.6	10.2			8.6	8.4	0.05	0.15	14	13	4	4	5
731	7.8	10.3			8.5	8.4	0.05	0.10	13	13	4	4	4
Average.....													
0.5													

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TABLE 1—Continued

Average analyses, first series, hot pipes (flow 1 gallon per hour May 1928 to January 1929. Flow 2.5 gallons per hour February 1929 to May 1930)

[illegible]





[illegible]





TABLE 2—Concluded

Brass, Cold										Brass, Hot									
PIPES	DISOLVED OXYGEN	FREE CO <sub>2</sub>	pH	TOTAL ALKALINITY	NEUTRAL ALKALINITY	TURBIDITY	COLOR	OXYGEN CONSUMED		PIPES	DISOLVED OXYGEN	FREE CO <sub>2</sub>	pH	TOTAL ALKALINITY	NEUTRAL ALKALINITY	TURBIDITY	COLOR	OXYGEN CONSUMED	
141	9.3	2.2	7.1	9	0	4	10	0.3		142	9.1	1.9	7.2	9	0	4	10	0.5	
341	9.4		8.1	12	1	4	10	0.2		342	9.2		8.1	13	1	4	10	0.4	
541	9.6		8.1	16	1	4	10	0.2		542	9.5		8.1	17	1	4	10	0.3	
Average.....									0.23	Average.....									0.40
Red Brass, Cold										Red Brass, Hot									
151	9.4	2.3	7.1	8	0	4	10	0.2		152	9.2	2.4	7.1	9	0	4	10	0.4	
751	9.7		8.1	12	1	4	10	0.1		752	9.5		8.1	13	1	4	10	0.3	
Average.....									0.15	Average.....									0.35
Copper Tubing, Cold										Copper Tubing, Hot									
1X1	9.4	2.4	7.0	8	0	4	10	0.2		1X2	9.2	2.4	7.1	8	0	4	10	0.4	
3X1	9.5		8.1	13	1	4	10	0.2		3X2	9.3		8.0	13	1	4	10	0.3	
5X1	9.7		8.1	16	1	4	10	0.1		5X2	9.5		8.1	17	1	4	10	0.2	
6X1	9.7		8.1	13	1	4	10	0.1		6X2	9.4		8.1	13	1	4	10	0.4	
7X1	9.6		8.1	13	1	4	10	0.1		7X2	9.6		8.1	13	1	4	10	0.2	
Average.....									0.14	Average.....									0.30

TABLE 3  
Average oxygen consumed (3.5 gallons per hour flow)

	STEEL	COCHOES WROUGHT IRON	BYERS WROUGHT IRON	READING WROUGHT IRON	GALVAN- IZED STEEL	GALVAN- IZED WROUGHT IRON	CEMENT- LINED STEEL	BRASS	RED BRASS	COPPER	LEAD
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
<i>Cold:</i>											
Raw .....	3.1	2.8	4.2	3.8	0.5	0.7	0.5	0.2-0.3	0.2-0.2	0.2	0.3
5 p.p.m. SiO <sub>2</sub> .....	3.7	3.3	4.5	3.9	0.4	0.7					
10 p.p.m. SiO <sub>2</sub> .....	3.5	3.5	4.0	4.0	0.5	0.7		0.2-0.2	0.2	0.2	
5 p.p.m. soda ash .....	3.5	3.2	4.4	4.2	0.5	0.6					
10 p.p.m. soda ash .....	4.0	3.6	4.5	4.7	0.6	0.5	0.4	0.1-0.2	0.1	0.1	0.2
4.5 p.p.m. lime hydrate ..	4.0	3.5	4.7	4.4	0.6	0.6		0.2	0.2	0.1	
4 p.p.m. caustic soda .....	3.8	3.9	4.4	4.4	0.5	0.6	0.5	0.2	0.2-0.1	0.1	0.2
Average .....	3.7	3.4	4.4	4.2	0.51	0.63	0.47	0.18-0.23	0.18-0.15	0.14	0.23
<i>Hot:</i>											
Raw .....	7.6	7.7	7.5	7.2	2.0	2.3		0.7-0.5	0.6-0.4	0.4	
5 p.p.m. SiO <sub>2</sub> .....	8.0	6.3	7.4	6.9	1.1	1.5					
10 p.p.m. SiO <sub>2</sub> .....	6.9	6.5	6.7	6.4	1.8	1.8		0.5-0.4	0.5	0.3	
5 p.p.m. soda ash .....	7.7	7.3	7.4	7.2	2.3	1.9					
10 p.p.m. soda ash .....	7.6	7.1	7.6	7.2	2.1	2.0		0.3-0.3	0.4	0.2	
4.5 p.p.m. lime hydrate ..	7.8	7.1	7.9	7.4	2.1	2.1		0.5	0.5	0.4	
4 p.p.m. caustic soda .....	7.6	7.5	7.4	7.4	2.4	2.0		0.5	0.5-0.3	0.2	
Average .....	7.6	7.1	7.4	7.1	2.0	1.9		0.5-0.4	0.5-0.35	0.3	
Series .....	1st	1st	2nd	2nd	1st	2nd	2nd	1st-2nd	1st-2nd	2nd	1st

TABLE 4  
Average loss of weight in grams of nipples at end of two years

	STEEL	COBES WROUGHT IRON	BYERS WROUGHT IRON	READING WROUGHT IRON	GALVAN- IZED STEEL	GALVAN- IZED WROUGHT IRON	CEMENT- LINED STEEL	BRASS	RED BRASS	COPPER
<i>Cold:</i>										
Raw.....	7.690	7.937	11.448	14.021	0.980	1.632	4.867	0.574	0.130	0.427
5 p.p.m. SiO <sub>2</sub> .....	10.974	12.602	13.892	13.163	0.773	1.494				
10 p.p.m. SiO <sub>2</sub> .....	11.694	10.892	12.537	13.738	1.180	1.451		1.283(?)	0.050	0.100
5 p.p.m. soda ash.....	10.088	8.426	11.816	13.775	1.113	1.329		0.281	0.025	0.427
10 p.p.m. soda ash.....	11.070	10.518	12.928	13.223	1.061	1.725	3.050	0.467	0.042	0.146
4.5 p.p.m. lime hydrate.....	10.821	12.190	14.143	13.557	1.013	2.257		0.372	0.030	0.115
4 p.p.m. caustic soda.....	10.766	10.877	14.035	14.180	1.093	1.895	2.687			
<i>Hot:</i>										
Location.....	B <sub>2</sub>	B <sub>2</sub>	B <sub>2</sub>	B <sub>2</sub>	B <sub>2</sub>	B <sub>2</sub>		B <sub>2</sub>	B <sub>2</sub>	B <sub>2</sub>
Raw.....	25.969	28.485	31.580	26.793	5.747	5.285		1.185	0.484	1.135
5 p.p.m. SiO <sub>2</sub> .....	22.805	21.720	25.123	23.409	1.315	2.721		0.019	0.059	0.039
10 p.p.m. SiO <sub>2</sub> .....	15.815	17.814	16.344	17.779	1.646	3.438				
5 p.p.m. soda ash.....	28.746	28.302	37.094	26.618	3.472	5.116		0.296	0.134	0.235
10 p.p.m. soda ash.....	27.131	23.944	32.277	24.109	6.215	9.052		0.306	0.166	0.351
4.5 p.p.m. lime hydrate.....	23.856	25.104	32.176	24.850	6.284	13.593		0.287	0.206	0.248
4 p.p.m. caustic soda.....	27.189	23.689	35.583	24.728	8.480	11.958				
Series .....	1st	1st	2nd	2nd	1st	2nd	2nd	1st	1st	2nd

ously stated by noting the seconds required to fill a water pail with the faucets wide open. Figures 3, 4 and 5 illustrate this point. Figure 3 shows flow by hot raw water and the various treatments

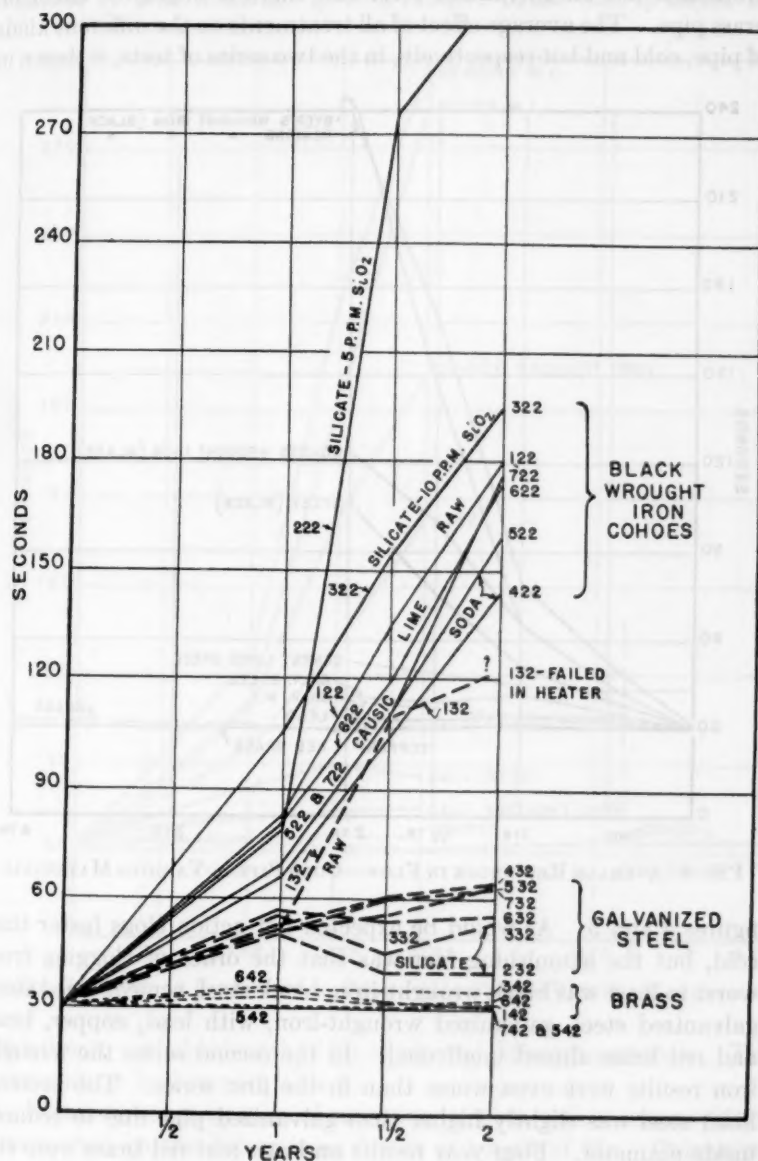


FIG. 3. REDUCTION IN FLOW—HOT PIPES—VARIOUS TREATMENTS

through black wrought-iron pipe, galvanized-steel-pipe and brass pipe. The silicate treatment on the iron pipe shows by far the worst clogging, the silicate treatment shows less clogging and thus some real protection hot on galvanized steel and there is negligible effect on brass pipe. The average effect of all treatments on the different kinds of pipe, cold and hot respectively, in the two series of tests, is shown in

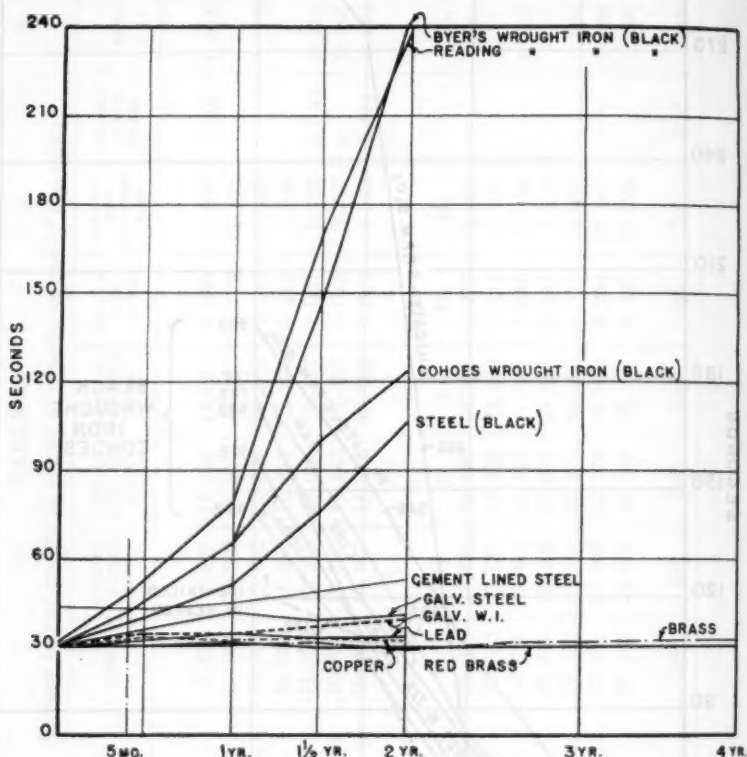


FIG. 4. AVERAGE REDUCTION IN FLOW—COLD PIPES—VARIOUS MATERIALS

figures 4 and 5. As would be expected hot action clogs faster than cold, but the astonishing fact was that the order of clogging from worst to least was black wrought-iron, black steel, cement-lined steel, galvanized steel, galvanized wrought-iron, with lead, copper, brass and red brass almost unaffected. In the second series the wrought iron results were even worse than in the first series. The cement-lined steel was slightly higher than galvanized pipe due to reduced inside diameter. Four year results on brass and red brass were still

negligible. The complete flow figures, as only a few have been charted, are shown in table 5.

Comparing the average oxygen consumption figures of all treatments by pipe materials gives a relative figure that is useful with

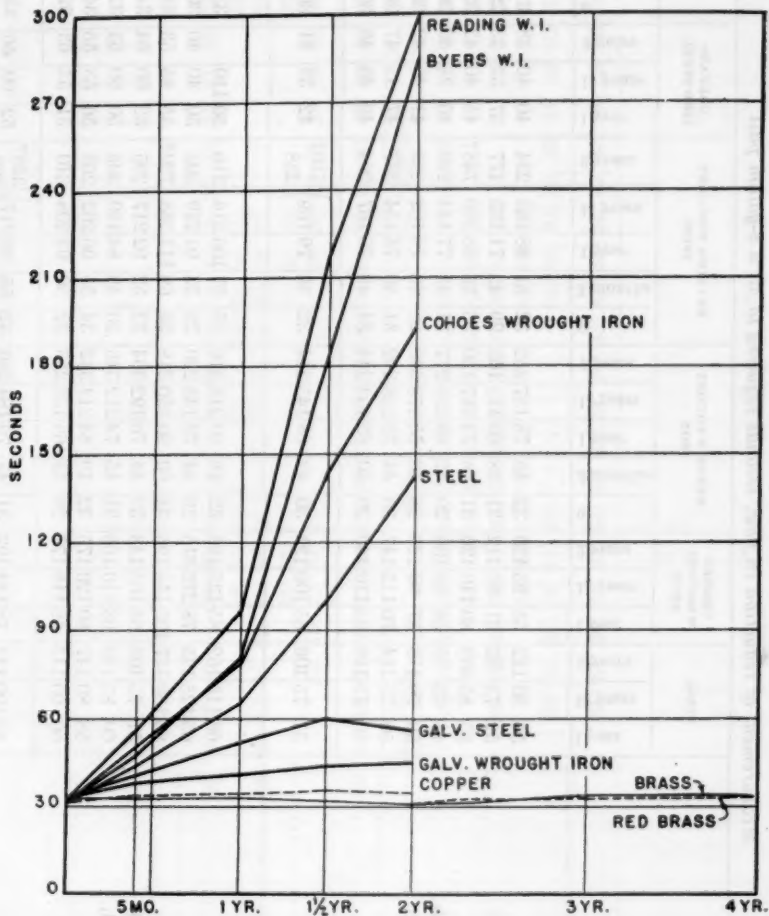


FIG. 5. AVERAGE REDUCTION IN FLOW—HOT PIPES—VARIOUS MATERIALS

relation to probable length of life of pipes of different materials. This comparison is shown in table 6.

However, concentration of corrosion in spots such as causes pitting may often be the determining factor of length of life. Galvanized

TABLE 5  
Measurement of reduction in flow, seconds required to fill a 3-gallon pail

	STEEL			CORES WROUGHT IRON			BYERS WROUGHT IRON			READING WROUGHT IRON			GALVANIZED STEEL			GALVANIZED WROUGHT IRON								
	1 year	1½ years	2 years	1 year	1½ years	2 years	0	3 months	1 year	1½ years	2 years	0	3 months	1 year	1½ years	2 years	0	3 months	1 year	1½ years	2 years			
<i>Cold:</i>																								
Raw.....	55	80	112	65	95	120	32	45	78	157	252	32	51	88	163	234	40	40	38	31	35	36	38	40
5 p.p.m. SiO <sub>2</sub> .....	52	75	92	61	95	112	31	38	60	112	163	29	43	71	133	177	37	35	33	29	32	33	32	33
10 p.p.m. SiO <sub>2</sub> .....	55	85	103	80	110	120	31	46	73	117	150	36	55	88	260	748?	45	40	42	32	37	38	39	39
5 p.p.m. Soda ash.....	48	65	85	58	85	100	29	42	68	159	277	31	48	77	144	220	40	35	40	30	35	35	36	40
10 p.p.m. soda ash.....	50	70	118	57	90	125	28	40	65	178	330	28	43	73	162	263	41	40	42	30	33	33	36	38
4.5 p.p.m. lime.....	50	75	114	70	115	147	30	44	70	158	292	31	50	78	154	237	47	45	47	30	34	36	37	40
4 p.p.m. caustic.....	50	75	116	63	110	140	29	40	62	134	244	34	49	79	167	294	42	40	46	30	33	36	38	42
Average.....	51	75	106	65	100	123	30	42	68	145	244	32	48	79	169	238	42	39	41	30	34	35	37	39
<i>Hot:</i>																								
Raw.....	66	115	162	85	135	180	32	48	90	218	316	35	57	106	216	310	50	110	33	42	44	48	48	
5 p.p.m. SiO <sub>2</sub> .....	65	125	135	78	275	315	29	44	90	145	220	29	53	91	219	305	50	40	40	30	37	36	37	38
10 p.p.m. SiO <sub>2</sub> .....	83	130	157	105	155	195	34	60	90	150	218	33	69	111	268	720?	55	45	53	34	41	43	44	44
5 p.p.m. soda ash.....	51	75	108	65	105	143	32	44	76	192	304	32	52	92	217	295	52	60	64	34	40	41	44	43
10 p.p.m. soda ash.....	60	85	140	68	110	160	31	45	74	212	346	30	48	84	190	305	50	60	63	32	38	40	44	43
4.5 p.p.m. lime.....	58	80	147	80	120	175	32	49	84	214	342	34	55	96	202	268	56	53	55	34	32	45	47	50
4 p.p.m. caustic.....	60	90	145	68	110	177	29	42	66	156	255	32	50	93	208	310	51	55	63	32	40	41	47	49
Average.....	65	100	142	78	144	192	31	47	79	184	286	32	55	96	217	299	52	60	56	33	39	41	44	45

	BRASS										RED BRASS					COPPER				
	CEMENT-LINED STEEL					BRASS (HOT)					RED BRASS (HOT)					COPPER (HOT)				
	0	5 months	1 year	1½ years	2 years	1 year	1½ years	2 years	26 months	31 months	38 months	44 months	50 months	0	5 months	1 year	1½ years	2 years		
<i>Cold:</i>																				
Raw.....	42	46	47	49	54	31	30	30	30	31	31	31	30	32	30	31	31	31	34	32
10 p.p.m. SiO <sub>2</sub> .....						34	32	32	33	35	35	35	35	33	33	31	31	31	35	34
10 p.p.m. soda ash.....	46	40	42	46	50	31	30	28	28	29	30	30	30	29	30	27	29	31	31	32
4.5 p.p.m. lime.....						33	30	31						32	30	30	32	32	32	32
4 p.p.m. caustic.....						53	55	52	30	29				30	30	28	29	29	30	32
Average.....	44	43	45	49	53	32	30	30	30	31	32	32	32	31	31	29	30	30	33	32
<i>Hot:</i>																				
Raw.....						35	34	35	33	32	31	33	33	33	34	33	34	34	36	35
10 p.p.m. SiO <sub>2</sub> .....						34	35	34	33	35	37	37	36	33	33	33	33	33	35	35
10 p.p.m. soda ash.....						35	32	34	30	30	29	30	32	31	31	32	33	29	29	31
4.5 p.p.m. lime.....						34	32	33	34	31	30					35	32	33	33	36
4 p.p.m. caustic.....																32	30	30	32	31
Average.....						35	33	34	33	32	31	32	32	34	33	32	31	32	32	35

metal does not stand hot action well in practice. Pin-holes cause leaks in hot water tanks frequently within five years with Catskill water. The raw water hot galvanized steel pipe became full of pin-holes in the heater and was soldered several times to keep it running to the end of the first series.

Brass pipe lasts very well with Catskill water, although probably red brass or copper will last longer in the hot supply. Composition materials such as in corporation taps that are used for connection of house services to the mains (copper 87 percent, tin 5.5 percent, zinc

TABLE 6  
*Comparison of effects of treatment on various pipes*

MATERIALS	SERIES	OXYGEN CONSUMED, P.P.M. (2.5 GAL. PER HR. FLOW)	
		Cold	Hot
Black steel.....	1	3.7	7.6
Black wrought-iron (Cohoes).....	1	3.4	7.1
Black wrought-iron (Byers).....	2	4.4	7.4
Black wrought-iron (Reading).....	2	4.2	7.1
Galvanized steel.....	1	0.51	2.0
Galvanized wrought-iron.....	2	0.63	1.9
Cement-lined steel (National Tube).....	2	0.47	
Brass, 60:40 (Plumrite).....	1	0.18	0.50
Brass, 60:40 (Plumrite).....	2	0.23	0.40
Red brass, 85:15 (Cuprite).....	1	0.18	0.50
Red brass, 85:15 (Cuprite).....	2	0.15	0.35
Copper tubing.....	2	0.14	0.30
Lead.....	1	0.23	

5 percent, lead 2.5 percent) is not corroded. Examination of the brass pipes used in these tests, made by polishing the cut surface, gives no indication of dezincification after four years service.

Lead pipe has been used for many years to connect buildings to the mains and serves for long periods of time without serious corrosion, although there have been instances of electrolytic corrosion.

Study of the tables containing oxygen consumed by periods throughout the tests indicates that the oxygen consumed in galvanized steel or galvanized wrought-iron in the beginning is practically as high as in black steel or black wrought-iron pipe, but it rapidly decreases so that in four to eight weeks it has stabilized at a low figure. This is

probably due to the dense oxide or carbonate film that forms on zinc as has been described by Baylis and others, in contrast to the porous tubercle that forms with iron to create a pitting cell. That the zinc that dissolves is in the form of carbonate due to action of carbonic

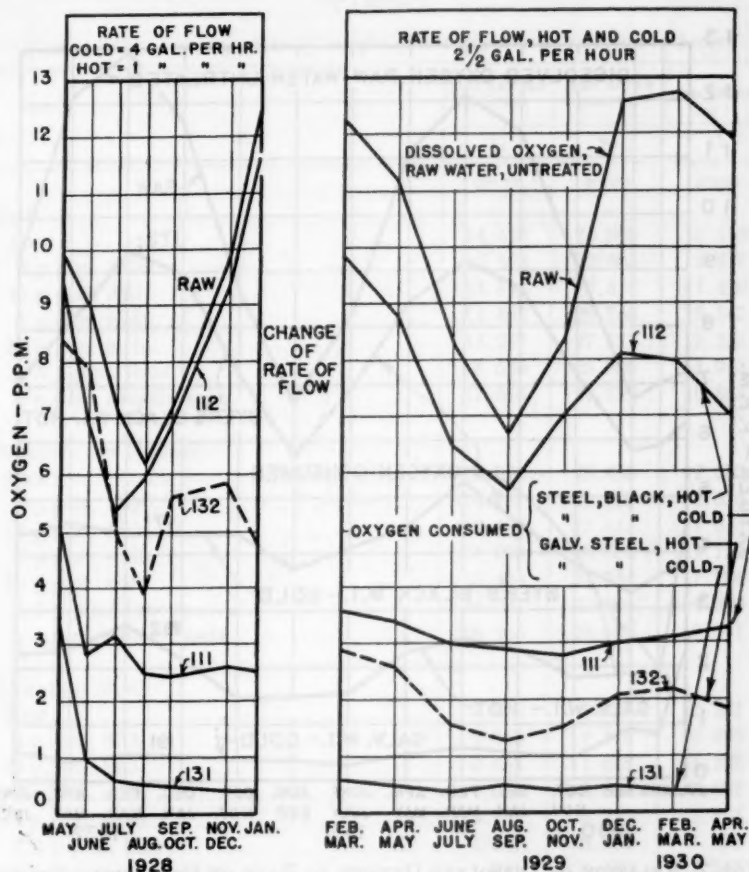


FIG. 6. RELATION OF DISSOLVED OXYGEN TO RATE OF CORROSION—SERIES I

acid as well as oxygen is shown by consistent increase in the alkalinity in the beginning with also neutral carbonate of zinc present at first.

The oxygen consumed varies to a large extent with the original amount of oxygen present in the water. This is readily seen in the results at various periods of time, the oxygen being higher in the winter and lower in the summer. Figures 6 and 7 demonstrate this

relationship with black steel, black wrought-iron, galvanized steel, and galvanized wrought-iron, cold and hot, and also show the sharp drop in oxygen consumed with galvanized pipe in the first two weeks.

The average loss of weight of nipples at various locations, hot pipes, for steel, Cohoes wrought-iron, and galvanized steel, in the first

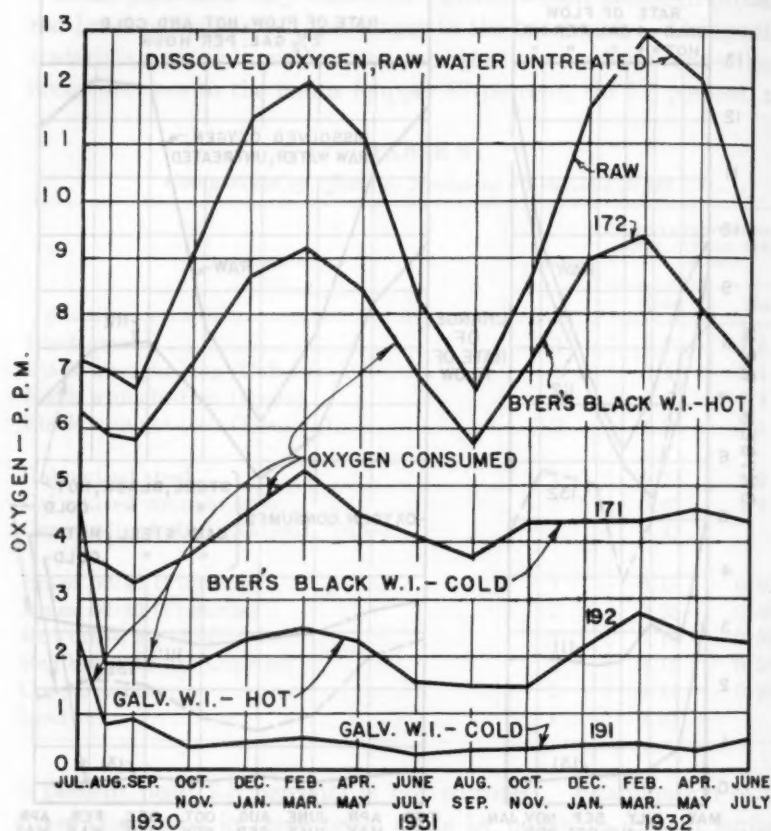


FIG. 7. RELATION OF DISSOLVED OXYGEN TO RATE OF CORROSION—SERIES 2  
(Rate of flow =  $2\frac{1}{2}$  gallons per hour)

series, are shown in table 7. The results with different treatments are also shown. The locations are just before the heater, just after the heater, and at the end of the pipes. It will be noted that the highest losses are just following the heater. This is due to the increase in carbonic acid by the effect of heat upon the bicarbonates and to the effect of higher temperature in accelerating chemical action. The

practical point is that whereas galvanized piping near a heater may leak, clog, and require replacement in 2 to 3 years, the greater part of the pipe in a hot water system may serve for 10 to 15 years before it fails to deliver sufficient water.

TABLE 7

*Comparison of average loss of weight of hot nipples in relation to heater*

	JUST BEFORE HEATER	JUST AFTER HEATER	END OF PIPE
	A <sub>1</sub>	B <sub>1</sub>	C <sub>1</sub>
	grams	grams	grams
<i>Steel:</i>			
Raw .....	14.520	25.969	10.156
5 p.p.m. SiO <sub>2</sub> .....	15.573	22.805	9.915
10 p.p.m. SiO <sub>2</sub> .....	14.898	15.815	11.420
5 p.p.m. soda .....	14.492	28.746	12.547
10 p.p.m. soda .....	15.267	27.131	15.295
4.5 p.p.m. lime .....	18.530	23.856	11.945
4 p.p.m. caustic soda .....	17.516	27.189	16.355
<i>Wrought Iron (Cohoes):</i>			
Raw .....	10.926	28.485	12.373
5 p.p.m. SiO <sub>2</sub> .....	14.751	21.720	14.014
10 p.p.m. SiO <sub>2</sub> .....	12.483	17.814	11.018
5 p.p.m. soda .....	11.288	28.302	11.755
10 p.p.m. soda .....	15.104	23.944	17.184
4.5 p.p.m. lime .....	14.627	25.104	14.300
4 p.p.m. caustic soda .....	16.365	23.689	13.641
<i>Galvanized Steel:</i>			
Raw .....	0.683	5.747	1.261
5 p.p.m. SiO <sub>2</sub> .....	1.016	1.315	0.673
10 p.p.m. SiO <sub>2</sub> .....	0.653	1.646	1.127
5 p.p.m. soda .....	1.039	3.472	1.597
10 p.p.m. soda .....	0.753	6.215	1.753
4.5 p.p.m. lime .....	1.357	6.284	1.823
4 p.p.m. caustic soda .....	1.081	8.480	2.247

The great rapidity of corrosion is shown by the fact that 42 percent of the dissolved oxygen present had gone in corrosive action cold and 79 percent hot in the black steel and wrought-iron pipes in the short time of contact of 38 minutes cold action and 50 minutes combined cold and hot actions only 29 minutes of which was hot. Again the loss of iron in hot action in the locations just following the heater was

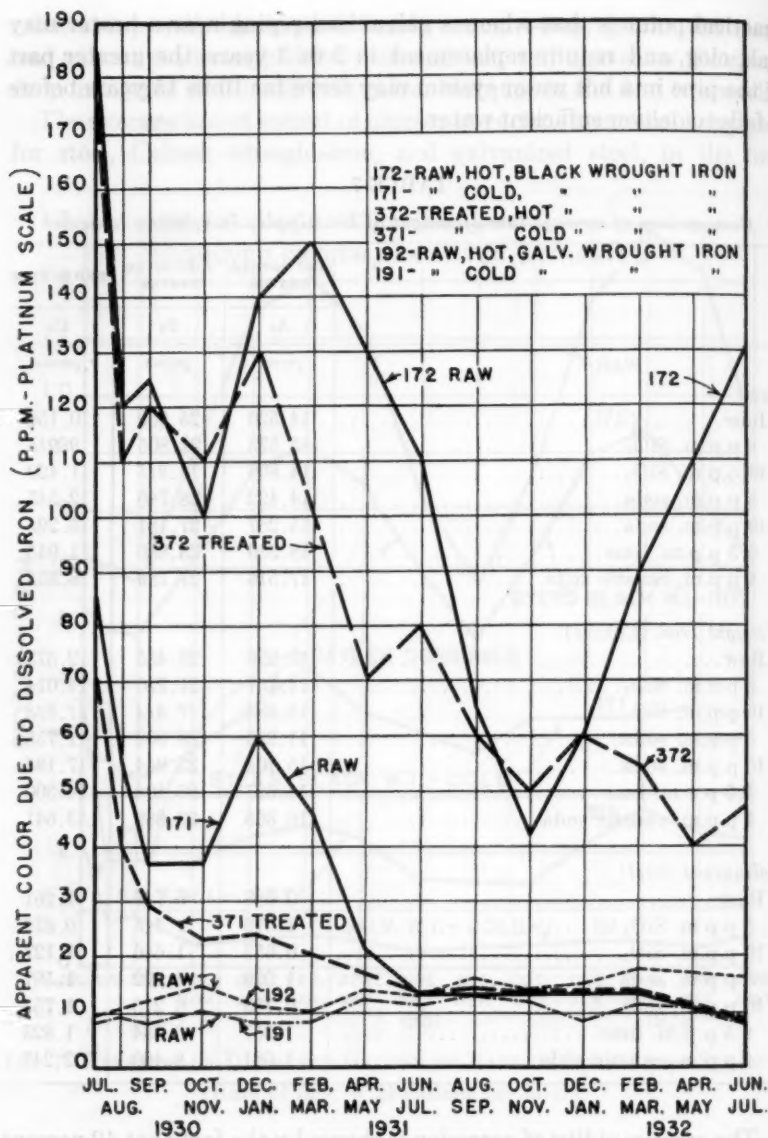


FIG. 8. RED WATER AS EXPRESSED IN APPARENT COLOR PRODUCED BY RAW WATER AND SODIUM SILICATE TREATED WATER IN BYER'S WROUGHT IRON PIPE, BLACK, HOT AND COLD AND COLOR IN GALVANIZED WROUGHT IRON PIPE, HOT AND COLD, RAW WATER—SERIES 2

(Rate =  $2\frac{1}{2}$  gallons per hour)

so great that the entire metal would be dissolved in about 20 years. Figure 8 expresses as color determination the dissolved or colloidal iron, cold and hot, carried to the tap in one of the black wrought-iron pipes by untreated water and by silicate treated water, also in galvanized wrought-iron pipe by untreated water. This demonstrates the severe red water that may occur with black or old pipe in contrast to galvanized pipe, and also shows no great effect of treatment. The results are typical.

That these waters were actually correctly treated to the extent desired is shown by the analyses. The pH of the fully neutralized waters averaged 8.0 to 8.4 in the two series. As corrosion progressed there was generally a slight decrease in free carbonic acid where originally present in the raw water and a slightly more alkaline pH.

In closing, a few words may be said concerning the chemical mechanism of corrosion and as to why oxygen consumed is a measure of the extent of corrosion. The first action is a dissolving of the metal to form a soluble bicarbonate at the same time setting free the hydrogen of the acid. This hydrogen would polarize the metal and stop the action if it were not removed. It may be partly removed mechanically by fast-flowing water, but is mostly removed by oxidation to form water by the oxygen generally present in water in solution as a gas. In the case of iron a secondary oxidation takes place from ferrous to ferric condition forming rust and setting free carbonic acid again from the ferrous carbonate, since the iron exists as an oxide in the ferric condition. This action goes on (so-called catalytic action) until all dissolved oxygen in the water is exhausted. Action will then continue until the ferric oxide ( $\text{Fe}_2\text{O}_3$ ) is reduced again to magnetic iron oxide ( $\text{Fe}_3\text{O}_4$ ) when the action stops. On account of the above reactions the decrease in dissolved oxygen in solution in the water is a relative measure of the extent of corrosion or its rapidity, particularly when corrosion has not gone the limit.

The details in the above experiments have been arduous and I must express my great appreciation for the excellent manner in which they have been carried out by Mr. Samuel Friedman, Chemist. Mention should also be made of Mr. R. W. Harvey, Master Machinist, who planned and constructed the mechanical layout of the equipment and plumbing.

The next series of experiments are as yet unfinished and cannot be included in the present paper. They comprise tests with varying amounts of excess lime hydrate and will show some very interesting results.

## THE PUBLIC WORKS ADMINISTRATION AND THE PRESENT OUTLOOK

BY WILLARD CHEVALIER

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A year ago at our annual convention we stood on the eve of the enactment of the National Industrial Recovery Act, one of the most far-reaching of the measures that had been sponsored by the Administration in connection with its general program for recovery. Other efforts had been directed to banking, agricultural and monetary considerations, but the National Industrial Recovery Act struck to the heart of the depression in that it sought to provide the stimulus to industry and trade required to start them back toward a more normal volume of employment and a more healthy functioning of all the economic processes.

### THE RECOVERY ACT: TITLE I

This measure consisted of two parts. The first, which established the NRA, dealt primarily with labor conditions and secondarily with trade practices that had a destructive effect upon business confidence and progress. Because of its reliance upon the arbitrary establishment of minimum wages and maximum hours the control of prices and other kindred factors this section of the act was destined to exert its greatest effect on those industries that produce and distribute consumer goods. It was obvious that higher wages and greater employment for the working man would make itself felt immediately in the demand for consumer goods, but more and larger pay envelopes could result in no immediate demand for those more durable materials and services that are involved in the process of capital investment and are known as capital goods.

No amount of arbitrary wage raising, limitation of hours or trade practice control could increase appreciably and immediately the demand for such goods or stimulate orders or employment in the industries that produce them.

This circumstance was the more important because it was just these industries that had felt the brunt of the depression. Recently

it has been demonstrated by figures from several independent sources that, broadly speaking, about half of the unemployed normally are engaged in the production of goods and the other half in the rendering of services. The demand for services moreover is contingent upon the production and distribution of goods. Of the unemployed normally engaged in the production of goods, only one-tenth are engaged in the production of consumer goods, leaving nine-tenths to the so-called durable or capital goods industry.

Combining those normally engaged in the production of goods with those engaged in the production of services, we find that between 90 and 95 per cent of the unemployment is dependent on the durable goods industries; until these are put back to work there can be no hope of striking an effective blow at the general business depression. It will be evident therefore that the NRA, established by Title I of the National Industrial Recovery Act, must be quite inadequate to accomplish the major purpose of the measure.

#### THE RECOVERY ACT: TITLE II

To achieve this was the purpose of Title II of the act. This provided for a comprehensive program of public works construction, both national and local, to be fostered and supported by the coöperation of the federal government. It provided funds for the resumption of many federal construction projects that had been suspended, authorized the prosecution of new federal projects including a substantial program of highway improvement and, through a system of loans and grants, sought to encourage a resumption of non-federal construction, the prosecution of which had been suspended or postponed because of a lack of sufficient capital through the normal channels of finance.

Thus it was planned to use the national credit to finance all types of public works construction and thereby stimulate some demand for the products and the services of the capital goods industries, put to work usefully as many of the unemployed as could find jobs either on the work or in the factories and mills producing the necessary materials and equipment and thus gradually build up purchasing power, stimulate industry and trade and give the natural forces of recovery a chance to exert themselves for the long pull. No one with an understanding of the values involved expected that any reasonable public works program could possibly make up for a complete absence of private investment and the program projected by the

National Industrial Recovery Act was intended to be no more than a cushion to take the impact of the depression upon these basic industries and a foundation upon which they could build back to a more nearly normal demand for their products.

An important segment of the non-federal works program was that made necessary by the need for improved water works and sanitation in thousands of municipalities both large and small. It was soon seen, therefore, that the interests of those affiliated with this association were closely bound up with public works enterprise, and it is appropriate that now, a year later, we pause to take stock of what has happened, estimate our present situation and consider what shall be our attitude toward the further development of the program.

#### PROGRESS OF THE PAST YEAR

In considering the progress of the past year our first impression must be one of disappointment. We have not accomplished as much as we hoped we might have accomplished by this time. It would be foolish to camouflage this feeling, but it would be equally foolish to accept it as a reason for discouragement or despondency as to our progress and outlook. It is in order for us rather to scrutinize the developments of the last year, to ascertain what have been the reasons for our disappointing progress and to plan our course so that we may profit by our experience.

It must not be forgotten that however meager may be our achievement as compared with our expectation there has been none the less a substantial volume of work during the last year that would not have been available if it had not been for the public works program.

In reviewing the shortcomings of the Public Works Administration, we are first impressed by the discouraging delays that attended its organization. It took too long to get to work. Some of this delay must be accepted as inevitable in view of the conditions, but much of it was unnecessary and inexcusable. Those who had sponsored the public works program had anticipated the need for prompt and energetic action if it were to be most effective. It was known that the 1933 season would be well advanced before legislative action could be had and that it would be necessary to set up a nationwide administrative organization of great flexibility if we were to take advantage of last year's construction season. Accordingly, a comprehensive organization was planned well in advance and with semi-official coöperation a well qualified personnel was selected, notified

to hold itself in readiness and otherwise be prepared to go into action just as soon as the bill was passed. General plans for procedure were fairly well worked out in advance and it was felt that a good start would be made.

Unfortunately all this care and labor was wasted because the passage of the act became a signal for a series of fumbles and false starts, caused by cross currents of political and personal influence that sacrificed ruthlessly the purpose of the act and wasted several months of invaluable time. The evils that resulted from this fumbling were more far-reaching than the mere loss of time, as they gave rise in turn to other developments that had an unfortunate effect upon the public's attitude toward the public works program and upon the seriousness with which the local communities undertook to apply it. Further reference will be made to this.

Another factor that tended to obstruct the operation of the public works program was the failure by many to discriminate between the relief function and the recovery effort. In many cases direct relief of the unemployed was necessary, and in their efforts to mitigate such conditions, some of those who were responsible for the conduct of public works projects sought to extend such direct relief by throwing as many men as possible on each job, even to the extent of boycotting the normal methods and tools of efficient production. A premium was put on manual labor in the field at the expense of the more highly skilled labor that would normally be employed in the shops and factories that produced the equipment normally used on construction. This "hand labor" fallacy took hold of many of our people and the capital goods industries, the stimulation in which was the major purpose of the act, were sacrificed in the interest of direct unemployment relief that never should have been carried on under its provisions.

#### WHEN THEY PULLED THEIR PUNCH

Still another obstruction was the attitude of some conservative members of the administration who were not wholly in sympathy with some of the President's recovery measures; their one concern was to achieve an ostensible balance of the federal budget without respect to whether specific expenditures were for current or capital account, and who did their utmost to turn the administration back from its liberal program to one of continued deflation. For a time the impression was rife that the authorized public works program

might be perverted into a mere gesture and that the so-called "natural forces" of recovery would make it unnecessary. All this, of course, was bound to be futile and destructive, but for the time being it had the effect of pulling some of the punch that should have been put behind the public works program from the beginning.

Another difficulty was the fact that, while certain federal projects which had been suspended earlier in the year were quickly restored by this act and while the highway program and many other large federal projects for which plans were ready were put under way promptly, communities throughout the country needed considerable time to prepare technically and legally for the prosecution of projects that had been shelved or that were not yet ready for immediate action. Many cities found it necessary to go to the voters for authority to issue bonds; others found it necessary to take legal action to validate the steps required to draw public works funds and still more had but a vague conception of what they must do in order to avail themselves of the privileges of the act.

All this called for a nationwide process of education for engineers, public officials and in many cases the general public, which took time and effort. In this process the American Water Works Association has done an outstanding job. Even before the enactment of the bill it had an organization in process of formation and it has carried on its work intelligently and consistently. The association deserves much credit for what it has accomplished within its field.

Closely related to the idea that natural recovery alone would pull us out of the depression without recourse to the public works section of the National Industrial Recovery Act was the degree to which public attention was focused upon the operations of the National Recovery Administration. The general adoption of the President's re-employment agreement with its provision for higher minimum wages and shorter working hours and the establishment of codes in certain industries that employed large numbers had an immediate effect upon the payrolls of those industries, which in turn served as a stimulus to certain consumable goods markets. This emphasized the operations of the NRA, reaching as it did into every factory and shop and every place of business, however small. Because of this, few realized that whatever temporary spurt might be felt by the trade in consumer goods there could be no general or enduring recovery until the capital goods industries had been energized. Even fewer realized that the accomplishment of this essential job was the purpose

of the second part of the act and during last summer and autumn we found ourselves lulled into a false sense of security because of the superficial and temporary effects of the NRA. Later it became evident that even these would be short-lived unless the durable goods industries with their vast unemployment could be revived. And soon it was obvious that the operations of the NRA could not accomplish that purpose.

#### EFFECTS OF THE CWA

Finally, and most damaging perhaps in its effects, was that episode of despondency known as the Civil Works Administration. This was a direct result of the delay in getting the public works program under way. Probably it would be inaccurate to say that if the public works program had been properly launched the CWA venture would have been wholly unnecessary, but it is a fact that the initial delay in the PWA did make necessary to a far greater degree than was desirable the scope of the CWA. Most unfortunate was the fact that CWA, being a relief measure entirely, was designed to furnish direct relief through nominal employment without respect to economic values. Undertaking to do this through jobs of a class that should have been carried on under the Public Works Administration, the public became confused and could not discriminate between a public works program seeking to foster industrial recovery and a civil works program seeking to sugar-coat a dole to the unemployed. In some cases public works projects which had been organized and were ready to get under way were perverted into civil works projects so that the local community might be relieved of bearing its share of the cost. New impetus was given to the "hand labor" fallacy and, generally speaking, the effect of the CWA was to undermine the morale of those whose energetic support was most necessary to make the public works project a success.

I believe that CWA or something akin to it was necessary last winter, but I deplore the delay in the public works program that had made it necessary and I regret that it was carried on in such a way as to undermine and demoralize for the time being the more far-reaching and essential operation of the public works program.

Another factor that affected the operation of the public works program was the establishment of wage scales both for PWA and CWA that had no relation whatever to the economic conditions that prevailed in the several communities. Division of the country into

three major zones and the establishment of blanket scales without respect to whether the work must be done in a small hamlet or a large city resulted in some cases in drawing workers from jobs in private industries on to the more liberal payrolls of public relief projects. Furthermore, the restrictions imposed upon those who were prosecuting public works projects as to the selection and use of labor introduced a hazard and an inefficiency that in many cases outweighed the value of the grant offered by the federal government to the local community. All of these had a tendency to defeat the purposes of the act.

#### THE GRIEF BEHIND US

In the foregoing I have dwelt upon the resistances and obstructions that have tended to impair its efficient operation. I have done this not to apologize for it, but rather to explain it; not to ascribe failure but rather to emphasize the substantial measure of success that has been achieved despite these obstacles. The outstanding factor in the public works program today is not that it has experienced all these obstructions but that, now they have been surmounted, it stands today upon the threshold of its greatest effectiveness.

Despite all the delays and ineptitudes of last summer we now have a nation-wide organization, well staffed and competent to handle promptly and intelligently a vast volume of work. Except for the few die-hards the whole administration and many business leaders now recognize that the public works program is an essential element in the recovery program. Gradually but certainly the emphasis has shifted from the domain of consumer goods to that of capital goods and today there is universal understanding that the former can effect neither a recovery nor even a permanent improvement until we have dealt effectively with the latter. After the educational work that has been carried out by the PWA, associations and individuals, our cities, towns and villages understand today how to go about getting PWA coöperation.

With the general improvement in basic conditions, municipal credit is improving at a rapid rate and many communities now find it possible to negotiate their own loans through normal investment channels and use only the grants made available by the Public Works Act. It is a matter of record that at the time the 1933 appropriation was exhausted non-federal applications were coming through in larger volume and of higher quality than at any time since the incep-

tion of the project. Moreover the CWA is behind us and with the lessons learned from that experience the administration is planning to handle future relief on a basis that will be more satisfactory both from the viewpoint of relief and from that of non-interference with the normal operation of the public works measure as a recovery enterprise.

On every account, therefore, we may look upon the last year as having shown a net gain, not alone in the relatively small volume of work that was put in hand but even more for the experience we have had and the lessons we have learned. Today we have a going concern all set up to drive forward with the greatest effect and at a time when a public works project can strike more telling blows against the depression than ever before.

#### PRESENT STATUS OF THE PROGRAM

At this point it may be well to summarize in terms of money the present status of the entire program. At the present time allotments for Federal projects amount to \$1,408,000,000. Of these, contracts have been awarded and force account work started to the amount of \$1,036,000,000, while actual expenditures amount to about \$253,000,000. Turning to the non-federal projects, we find allotments amounting to about \$770,000,000, contracts awarded \$323,000,000 and expenditures estimated at only \$64,000,000. This means that, of the allotments that have been made, about 62½ percent are represented by contracts awarded while only 15 percent are represented by expenditures actually made to date. This indicates why the peak of the public works effort is yet to be felt during the construction season of 1934.

Coupled with these figures is the determination on the part of the Public Works Administration that greater speed must be made in turning these allotments into expenditures. Already the administrator has rescinded many of the allotments to non-federal projects because of delay in getting them under construction and already this has had the effect of stimulating dilatory jobs and of making certain rescinded funds available for projects that are ready to go ahead promptly.

In the water-works field we find that, of the water-works contracts awarded during the first five months of the year, 42 percent were independent of PWA while 58 percent were made possible by PWA loans and grants. In actual volume of contracts awarded the first

five months of 1934 show a gain of 59 percent over the first five months of 1933, if we eliminate certain exceptionally large contracts that were awarded in California a year ago.

The indications are that this progress will continue, as the water works lettings scheduled for the first five months of 1934 have shown a consistent increase in number. Of these, PWA allotments account for a substantial share; these will show a still further increase in May and June. Another circumstance that will tend to make PWA funds more productive of work is the improvement in municipal bond sales. If it is necessary to draw from the PWA funds only the amount required to cover the 30 percent grant and if the communities are able to finance the remainder of their projects through the private investment market, it is evident that PWA appropriations will go farther; moreover, the opportunity to participate in the grants will be an additional stimulus towards many communities undertaking water-works improvements at this time. During the first five months of 1933 total municipal bond sales for productive purposes amounted to about \$50,600,000; during the first five months of 1934 they have amounted to more than \$129,000,000, this being a gain of 155 percent.

#### THE NEED FOR CONTINUED EFFORT

In view of this record of accomplishment under difficulties and of the organization, experience and education we have inherited from the past year, it is clearer than ever that there is continued need for the Public Works Administration and for the effort of which it is the essential motor.

As has been said, the most substantial contribution that the public works program can make to recovery is to provide a stimulant to help revive private enterprise and private investment, but it must be remembered that capital investment and the industries dependent upon it thrive only on the confidence of the people. Investment implies confidence in the future and in future earning power. Unless we have that there will be no resumption of private investment, despite the expenditure that we may make through public agencies. We have not yet achieved an adequate measure of that confidence and until we do achieve it we cannot expect private business and industry to take up the burden and resume those normal processes upon which depend the basic capital goods industries.

During recent months many contractors and industrialists who

find employment on public works or who produce the materials and equipment used on such work have taken welcome jobs and booked welcome orders. It is noteworthy, however, that when it comes to investment in new equipment or new plant beyond their current needs they are most reluctant to commit themselves because of uncertainty as to how long the program will continue. They are living from hand to mouth and making old, obsolete and sometimes inefficient equipment do. So long as these men are uncertain as to the continuity of this work they will limit their investment to a minimum. Just as soon as they feel sure of a continuing volume of work they will junk the worn-out stuff and invest in new plant, new equipment and new facilities. Then only can we expect a revival of the essential capital goods industries.

If we multiply such instances by thousands we shall have a picture of the state in mind in industry today. Business is coming back. Industry and trade feel the first stirrings of recovery. They are getting orders. There is need for equipment and machinery of every sort to replace that which has been worn out during the years of deferred maintenance and obsoleted by progress in design during the last few years. Yet management hesitates to make these investments because of the uncertainty as to whether there will be a continuing need for it, a need for it beyond the present year and the present appropriation.

At this moment, therefore, the dominant need in the public works policy is for continuity. The essence of ultimate success with the program is this guarantee of continuity. For just a moment there is a guarantee of a continuing market, there will be a renewed and rejuvenated demand for capital goods and equipment of many sorts; as this is met, increasing activity will bring the confidence that will lead private business and private industry to make additional forward commitments and gradually feed capital back to work through its normal channels.

The public works effort has frequently been likened to the priming of a pump; the essential of this process is that we continue to prime until the pump surely takes hold. If we delay or hesitate or falter the result is that we use up a lot of water without having accomplished our purpose; our effort is doomed to wasteful failure unless we insure its continuity until private business and industry beyond question has taken hold. Regardless of how much we may appropriate for any given year, the ultimate success of the program depends on the

certainty that there will be available a continuing program for next year and, if necessary, for the year after that. I believe that if this assurance can be given to American industry today we probably shall need but a small part of whatever commitments may be made toward an appropriation for this purpose.

The surest way to guarantee economy in the prosecution of the public works program is to guarantee this continuity; the surest way to insure extravagance and waste is to dole it out one drop at a time with no certainty as to whether there will be another drop to follow. In other words, here is an occasion when boldness is of the essence of economy and hesitation and uncertainty are of the essence of extravagance.

#### CREDIT FOR CONSTRUCTION OR FOR SPECULATION

Another reason why it is so important to maintain the public works program in the interest of general recovery is the desirability of assuring that our available capital and credit be invested in useful and serviceable wealth such as is represented by well-conceived public works rather than dissipated in destructive speculation. Today we have enormous bank and treasury reserves which are available to finance a vast program of credit inflation. If, pending the resumption of investment by private business and industry, we do not provide a channel through which this credit may be put to work constructively, it will find its way into speculative channels to finance another inflationary boom. This might be very much to the liking of the brokers, but it certainly would be very much to the detriment of continued progress and substantial recovery for the rest of the country. It is important that we put our reserves to work constructively, preferably through the effort of private enterprise, but if necessary for the time being, through the construction of public facilities.

It is increasingly desirable also that we accelerate our efforts to provide regular employment in the durable goods industries so that we may reduce the necessity for continuing direct relief to the unemployed. Investments in public facilities that increase the community wealth are constructive. They may properly be funded over a long term; they have a natural limit in volume. Expenditures for direct relief on the other hand may have no limit. They are an abnormal and unnatural expedient; they put a premium on dependence and irresponsibility. They represent a current expenditure

that should not in the nature of things be met by long-term funding. They are exactly the stuff on which unbalanced budgets thrive, and in attempting to deal with them there is always the danger of unchecked inflation. It is of first importance that we get our public financing on the basis of a balanced budget for our current expenditures and of funding only our investments in durable wealth. Otherwise we court a monetary collapse, chronic unemployment and a growing spirit of irresponsibility among the people. As private business and private industry resume their operations and provide employment for more and more of our people this danger will pass; meanwhile the public works program offers the only means by which, through community effort, we can bridge the gap and provide a safeguard.

I know that in some quarters it has been the vogue to discredit the recovery effort by asserting that many of these plans and expedients have been tried in the past and that they have not been successful. I challenge both the statement and the conclusion. It is true that at various times in the past measures have been used that have been called by the same name as the present effort and superficially were of the same character. I am not at all convinced that the conditions under which they were applied corresponded in any substantial respect to ours, or that their principle and practice were on all fours with those we are now seeking to apply.

More specifically I believe that most of those enterprises were intended primarily as a relief measure. In general they have been a form of camouflaged dole, more comparable with the civil works administration than with the public works administration. Such projects are inherently unsound because they are not directed toward the use of the public credit to stimulate the normal processes of industry, but rather to direct relief as a substitute for normal employment. Whatever may be said with respect to any so-called public works program for relief that may have been tried in the past cannot be applied without careful discrimination to the present program of public works in the interest of industrial recovery.

#### WHAT IS THE TEST OF SUCCESS

But despite all this I am not convinced that we are justified in concluding that such enterprises in the past have failed. By what yardstick shall we measure success? No one should be so foolish as to believe that any policy of public spending alone can achieve

prosperity. That will come only with the resumption of normal enterprise and normal trade. The best that any public works program can do is to provide a stop-gap, to effect a transition between the temporary abdication by private enterprise of its responsibility for employing the people and its resumption of that essential rôle.

Success or failure, therefore, must be measured not by what positive results were accomplished by the program but rather by what disasters were escaped. I have described the civil works administration as an episode of despondency. On economic grounds it could not be justified. It contained the seeds of many abuses; it actually produced many abuses. It was an interference with the process of economic recovery that for the time being set it back substantially. Yet when all has been said and done, who dare say what might have happened if this measure had not been used? Who dare say that in the earlier instances that have been cited greater evils and disasters would not have come had it not been for those measures that now are condemned as failures? The tendency to discount the value of such measures in the past arises from the use of the wrong yardstick of performance. We should judge them rather by the evil from which they saved us than by what positive good they accomplished. At best they are palliatives, designed to save a situation while we generate those forces which alone can carry us forward to more normal and prosperous conditions.

Then, too, we hear much in these recent days tending to disparage other governmental efforts toward recovery. We are told that they but "interfere" with the so-called "natural processes" of recovery. We are even admonished that, after all, "deflation must run its course" and that we should be better off to "take it" and have it over with.

I am curious to know where were the prophets of natural recovery on March 3, 1933. Where were those who now demand so urgently that we avoid interfering with "individual initiative" that we "keep the government out of business" and that we should be better off "to let deflation take its course"? I wonder where they were even before that, when the line was forming at the entrance to the R.F.C. and governmental credit was being pumped into tottering financial institutions and other business organizations.

The theory then was that this credit would be passed on down from the top through industry and make employment for the unfortunate workers who, through dismissal, had been deprived of their livings

as their contribution toward the process of deflation. That was the theory, but experience has taught us that if we are going to provide employment for the people and enable them to survive an emergency that strikes down their opportunity to earn a living, we had better turn the public credit directly into jobs, even at the risk of "interfering with natural processes" that do not seem to proceed when they are most needed. But in those days we heard nothing about government "interference"; on the contrary, the structure of American industry and finance collapsed in the front yard of the government at imminent risk to our whole economic and social order.

Sometimes I think that Walt Disney has given to us unconsciously the most penetrating comment that has yet been offered on this attitude of disdain toward government "interference." You will remember that the three little pigs were very scornful and cocky while the wolf was out of sight, but when that grim wolf of depression and deflation (of whom, who's *now* afraid?) came crashing at the door, they lost no time in scotching under the bed in the substantial home of governmental credit.

And if today private business is in position to pick up its scattered fragments and rebuild anew the structure of profitable employment for capital and labor, it must remember that it enjoys this opportunity only because government did interfere in an hour of demoralization and despair, and because during the last year and a half it has held the economic and social fabric together so effectively that there is a chance for a new start. The job is not yet finished; much remains to be done. If at this time the government withdraws prematurely from the task it assumed in the public works program we may find that we have ruined our chances of building upon the work of the last year. It is better to be sure than to be sorry.

#### A JOB STILL TO BE DONE

Turning to the practical problem of insuring a continuous program we find that progress on federal work has been reasonably satisfactory and that from the nature of many of these projects there is an assurance of continued effort over the next two years. Legislation by the present Congress doubtless will provide a reasonable degree of continuity for the road-building program. The need for increased effort is in the direction of non-federal work in which of course municipal water works must be a substantial element.

It is evident, therefore, that sustained effort should be applied

through the local communities to have them take advantage of the opportunity now offered to build necessary public works with the coöperation of the federal government. As general conditions improve, this will become more and more unnecessary, but for the time being it is important to maintain a continuity of interest and effort. Additional funds for the PWA will be made available by the present Congress either by earmarking or by granting to the President ample discretion to make use of available resources. There are many signs of a new awakening on the part of many to the urgent need of maintaining the program and guaranteeing its continuity so long as may be necessary.

The water-works industry is in a position of great strength to present its case for consideration. It is engaged in the provision of a service that is fundamental and essential to our modern civilization. Thousands of communities need new, improved or more efficient water supplies. A very large portion of such projects are and can be made self-supporting. If we may assume a resumption of our normal growth it is almost impossible under present conditions for any community to invest in water works facilities beyond what it will need during the next five or ten years. Of all the facilities represented by our public works, none is more basic and none can more fully justify the investment of our people's savings than the one represented by this industry.

There is every reason today why it should continue its organization and its efforts to educate citizens, public officials, both local and national, and legislators to continue the public works program until it has accomplished its purpose of stimulating normal enterprise. Any other course would mean that we are abandoning the field just as victory is imminent and that we risk being forced into a futile and demoralizing policy of direct relief that may lose us all of what we have gained.

## PUBLIC WORKS AND WATER SUPPLY CONSTRUCTION

BY ABEL WOLMAN

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Long before the present depression some thoughtful workers in the engineering field had commented upon the fact that there was little, if any, evidence of conscious planning both as to time and amount of desirable public works. It has been almost universally true in the past that large expansions of public work have taken place during periods of prosperity with enormous retrenchment during periods of depression.

This cycle of events has ordinarily been assumed to be due either to chance or to lack of foresight and hence certainly unwise. It is important to note, however, that this has been only an assumption, because upon this assumption rests the conclusion most frequently presented today that this cycle should be artificially adjusted so that large public works construction could be increased during depression and decreased during prosperity. In other words, most of the recent emphasis has been on adjusting past procedure so that public work might take up the slack during the collapse of private industry, permitting private industry to resume its function more completely during periods of prosperity.

In view of this and other assumptions, it is time that we review critically the three major aspects of a public works program in order to determine what our position in the determination of such a program should be. In such a critical review several of the problems are susceptible to quantitative measurement. Others, unfortunately, can be evaluated only upon the basis of judgment, emotion, or wish fulfillment. These latter evaluations, again, are by far the most important and are the least likely to be objectively reviewed.

The problems concerning us may be approximately limited to three:

1. What is the amount of public work necessary during a given time?
2. When is the logical and least disturbing time in which to carry out extensive undertakings, and
3. How is the best way to do it, through Federal, local or combined auspices.

The writer intends to comment briefly on each of these aspects, in the light of his past two or three years' experience with them. He has had an opportunity, as State P.W.A. Engineer, as State Advisory C.W.A. Engineer and as a member of the Regional P.W.A. Advisory Board for Region No. 10, to watch closely the development of public works activities in its many ramifications and has become more fully aware as the months have passed of the difficulties which arise from undue generalization on this complex subject. The comments which are made here are necessarily tentative only and subject to such adjustment as may appear desirable as the result of future events.

#### AMOUNT OF PUBLIC WORKS NECESSARY

Most of the criteria of the amounts of public works necessary which have appeared in the engineering and lay press during the past two or three years, appear to rest on the fallacious assumption that the annual expenditures for public works for the period 1920 to 1929 inclusive should be taken as the norm for future expenditures. Under our present economic system the ruling criterion of the amount of public works necessary at any one time must be closely related to the capacity and the willingness of the public to pay. When this criterion is applied to 1934 it is by no means obvious that the figures of 1920 to 1929 should be the controlling base.

In the water works field alone no doubt a great many hundreds of millions of dollars could be profitably spent in the extension and development of public water supply systems. There is always the problem, however, of determining upon the economical rate of expenditure and of meeting the costs of such expansion.

Most of the statistical surveys of probable necessary public works are highly optimistic in amount and may be conservatively cut in half, without disturbing strongly the value of the projects. Unfortunately, many of the estimates of public works represent similar high degrees of wish fulfillment, rather than evidences of practical necessities. It is our firm conviction that such grandiose statistical predictions of public works necessity do more harm than good if they are to be translated into actual expenditures.

Perhaps the best estimates of the total volume of public construction in the United States in the recent past are those which appear in the studies of the National Bureau of Economic Research made in 1930.<sup>1</sup> According to the tabulations and checks there presented,

<sup>1</sup> Planning and Control of Public Works. National Bureau of Economic Research, Inc., New York, 1930, page 108.

public construction in the United States increased from approximately \$2,000,000,000 in 1923 to approximately \$3,600,000,000 in 1928. Suggestions, therefore, for public works bond issues in periods of depression running all the way from 3 to 12 billion dollars should make us all pause and determine as to what road toward recovery one should take, keeping in mind always that the principle aim of large public works expenditures under these difficult conditions is to stimulate private industry for as prompt resumption of work as possible, considering that this latter industry furnishes employment normally to more than forty million workers. Of over 9,000,000 unemployed, as estimated by L. P. Ayres for March, 1934, approximately 4,000,000 were in the group producing services and about 5,300,000 producing goods. Of this last group 2,027,000 were unemployed of the construction industries and 2,709,000 of other durable goods industries. In other words, about 5,317,000 unemployed can return to work only if the durable goods industries resume business. They represent "the important key to the unemployment situation."

This important phase of our recovery efforts cannot be too strongly emphasized if we recall that of the average money value of total construction per year in this country, for the period 1925-29, of \$10,900,000,000, private construction accounted for \$5,100,000,000, utility companies for \$3,000,000,000 and public works for \$2,800,000,000.

During 1933, approximately \$3,100,000,000 were spent for construction. Of this amount, private construction accounted for only \$700,000,000, utility companies for \$1,100,000,000 and public works for \$1,300,000,000.

In the light of these comparative figures, one cannot escape the disconcerting conclusion that one of the primary outlets for employment is not only not recovering, but appears to be declining further in inactivity. The figures likewise demonstrate that unless the Federal government proposes to take over all construction activities, its public works enterprises cannot be expected quantitatively to fill the gap, since they represent only a small fraction of the normal market for durable goods.

The further effect of large Federal public works expenditures, with rising and congealed labor and material costs, and of the prospect of inflationary monetary programs, among other things, apparently is to raise "investors resistance" to the point where the durable goods industry may expect little aid from private money, its primary source

of life blood in the past. One of the many indications of this disinclination of private money to flow into construction is given by the following statistics<sup>2</sup> of the number of dwelling units provided during the past years for each 10,000 of population:

<i>Year</i>	<i>Number of Dwellings per 10,000 People</i>
1925	121.8
1921-30 decade	92.5
1931	21.4
1932	5.9

#### WHEN SHALL PUBLIC WORKS BE BUILT

There is great fascination in the belief that when private industry is at its lowest ebb public operations should fill in the gap. On the face of it, this appears logical. It is not so crystal clear, however, when the causes of depression are more carefully analyzed in relation to a public works program.

Economic collapse has almost always been preceded by economic over-expansion. Retrenchment still appears logical as the most effective measure for recovery. It is still difficult to understand how the result of over-spending may be either avoided or dissipated by further spending.

I can do no better in this connection than quote the recent comments by Prof. Sumner H. Slichter of Harvard University.

"Public works are subject to the important limitation that they support markets, but do not remove the fundamental maladjustments which precipitate depressions. And, although I reject the view that unrestrained and uncontrolled liquidation is necessary to produce the price relationships which will permit a revival of business, I stress the fact that attempts to support the market for capital goods may defeat their purpose by keeping up the very prices which must fall in order to make a resumption of growth profitable. The danger is particularly great in case the public works program is of large magnitude and is started early in the depression. For this reason, as well as to avoid the deflationary effects which follow from fear of inflation, I conclude that public works programs of the long-range planning type, constructed on the basis of the ability and willingness of the community to bear the cost, are preferable to programs of the market-supporting type and that the construction of public works should

<sup>2</sup> Report to The President of the United States on National Recovery and Employment, by the Durable Goods Industries Committee. May 14, 1934.

not begin until the prices of capital goods have had an opportunity to fall. Indeed, public works might be used to induce a prompter fall in these prices. The government might predicate its willingness to expand construction by a given amount upon the willingness of building labor and producers of material to accept a given reduction in their prices.

"These conclusions point to the further conclusion that public works are least valuable precisely when they are needed most. They may be of great help in accelerating the revival of business—when they are least needed—but they are of little use in the early stages of the depression when things are going from bad to worse. They may be of considerable help in mitigating depressions of moderate severity, but they are of little or no help in halting a drastic decline. For example, even a very large program of public construction would not have halted the avalanche of world deflation in 1931 and early in 1932, and, by undermining public credit, it might easily have added to the avalanche."<sup>3</sup>

Obviously, the decision as to when a public works program is necessary is intimately bound up with important problems in economic philosophy, a field in which my ignorance is great. The point need not be labored further except to indicate that it is by no means obvious that large public works expenditures are either desirable or should be pressed during periods of great depression.

Although it is difficult in these times to separate sentiment from logic it should not be forgotten that the use of public works to reduce the volume of unemployment is not a modern invention. Ample evidence exists during the past century of similar efforts to stem the tide of depression difficulty. The startling thing about this evidence, however, is that we pay relatively little attention to it.

England has had many years of experience in the application of this device to the very purposes which we are discussing and investigations of its success or failure have been made by Sidney and Beatrice Webb. These authors, writing of the investigation of the operations of the Poor Law in England from 1886 to 1905, state that the reports of the special investigators for the Poor Law Commission of 1905-1909 "reveal the local authorities, at first reluctant to spend the rate-payers' money, gradually yielding to the pressure exerted by public opinion, by the House of Commons and by the

<sup>3</sup> *Economics of Public Works*, by Sumner H. Slichter, *The American Economic Review*, Supplement, March, 1934, pages 174 to 185.

Local Government Board, and striving to devise any form of useful work on which to employ the local unemployed. The old expedients are again employed. The local authorities again revert to hand labor on the roads, instead of sweeping and repairing by horsepower or steam-driven machines. They lay out more new parks and recreation grounds, and effect costly sewerage schemes and street improvements. But one after another they find it as impossible as before to adhere to the idea that 'the wages paid should be less than the wages ordinarily paid for similar work.' Any such attempt to discriminate in wages between the ordinary municipal staff and the extra men taken on as 'the unemployed' not only produced disgust and angry rebellion, but also, when piece work was made the basis, led to respectable and well-conducted men earning less than they needed for bare subsistence. . . . There was "renewed swamping of the lists (of unemployed) not by men from permanent situations, but by men who had been at no time more than intermittently employed. . . . This meant, as before, only a series of short jobs for each man, with the result not only of positively increasing all the evils of casual labor, but also of creating a permanent dependence on an endless succession of these artificially manufactured municipal jobs, which it was impossible to maintain indefinitely. Moreover, as it was found impracticable to pay lower rates than were normally earned by the lowest grades of unskilled laborers, who swarmed into the relief works, there seemed nothing to be done but to restrict the jobs to a few days in the week, or to one week at a time, for each man taken on, during the whole course of the winter. And every local authority in succession once more discovered, as their predecessors of the 18th and 19th centuries had done, that every such attempt to 'set the poor on work,' even at the lowest possible wage, and even where safeguarded by systems of piece-work remuneration, was prodigiously costly. Every piece of work took longer to perform than had been expected, and involved considerably more expense than it was on any computation worth. Nor did it all go to the unemployed. To supply the materials, provide the horses and carts and other necessary plant, and pay officers for the direction and supervision of the work, to be carried out by unskilled, inefficient and not very strenuous labor, proved ruinously expensive. . . . Finally it came to be recognized, even among the workmen, that it was impossible, in this artificial manufacture of municipal work, to avoid anticipating the ordinary employment of the permanently engaged

staff of laborers, or that of the contractors, so that the very employment of the Unemployed was creating, for the future, even more Unemployment.

"We cannot imagine a more conclusive test of the value of provision for the Unemployed by way of municipal relief works of the most varied kinds, in many different towns, under all sorts of administrators and in the most diverse circumstances, than that afforded—in succession to the previous experience between 1836 and 1880 and to that of the widespread and repeated series of experiments of 1886–1905, by the operations between 1906 and 1909, under the Unemployed Workmen Act."<sup>4</sup>

Prophecies of complete collapse, in the absence of large scale public works enterprises or because technological advance presumably has made it impossible for a country to recover, should likewise not be given undue weight in the minds of most of us, pressed by the necessities of the day. The extract below from the first annual report of Carroll D. Wright, Commissioner of Labor of the Interior Department of the United States, under date of March 17, 1886, sounds strangely familiar today. The significance of his statement lies in the fact that he was wrong. The extract is as follows:

"This full supply of economic tools to meet the wants of nearly all branches of commerce and industry is the most important factor in the present industrial depression.

"It is true that the discovery of new processes of manufacture will undoubtedly continue, and this will act as an ameliorating influence, but it will not leave room for a marked extension, such as has been witnessed during the last fifty years, or afford a remunerative employment of the vast amount of capital which has been created during that period.

"The market price of products will continue low, no matter what the cost of production may be.

"The day of large profits is probably past.

"There may be room for further intensive, but not extensive, development of industry in the present area of civilization."

If, however, public works are undertaken, we are led to the next problem, on how best to proceed.

<sup>4</sup> Sidney and Beatrice Webb, *English Poor Law History: Part II; The Last Hundred Years, 1929, Volume II*, pp. 653 ff. *Planning and Control of Public Works—National Bureau of Economic Research, Inc., New York, 1930, pages 169 and 170.*

## HOW SHALL A PUBLIC WORKS PROGRAM BE CARRIED OUT

During a period of economic sag, it is quite clear that the agency which has the greatest potentiality of financing large public works is the Federal Government. Although a number of states and municipalities are scattered throughout the country which are still in good financial condition, the areas which need public works operations are usually those which are wholly unable to finance them through local funds. These facts necessarily point to the selection of the only remaining agency for the performance of the work, namely, the Federal Government.

A number of choices then appear as to the financial, legal and engineering techniques of such a program. Problems of local autonomy, of unpreparedness, of variations and confusions in law and of inadequacies and unevennesses of financial structure then soon appear to hamper rapid progress.

Many people have been highly critical of the slow rate of operation of the public works program in this country. No one can deny that actual progress has been slow, but to indicate how it could be speeded up is a much more difficult task.

Careful review of the situation to date indicates quite clearly that either complete 100 percent Federal financing or the relaxation of Federal regulation of its partial contributions, with the necessary risks attendant upon such relaxation, are the only ways out if a similar program should be developed at any time in the future. Conviction on either score is not easily attained, since there are advantages and disadvantages on both sides.

Where the Federal Government is making a conscious effort to extend its credit under the most rigid financial controls possible, two results naturally occur:

1. Those areas which need public works stimulation to the greatest degree, namely, those which were most severely hit by the depression, are least able to avail themselves of the Federal credit.

2. Operations are decidedly retarded until all of the legal and financial phases of such contractual arrangements have been completed to the satisfaction of Washington.

One hesitates to indicate how either of these obstacles to rapid execution of work may be eliminated. There is ample evidence in the execution of other enterprises during the past year by one hundred percent Federal financing, that a program developed under Item 1, by one hundred percent Federal financing, brings with it a

number of dangers. By no means the least of these dangers is the complete collapse of local initiative, participation or responsibility.

When we refer to the delays inherent in item 2, are we ready to suggest that Federal money be disbursed upon a loan basis without a reasonable degree of assurance that such loans are honestly and completely secured? Wholesale default on Federal loans is perhaps the only answer to such a problem. The writer, at least, is not ready to take this road.

One of the further retarding causes has been the lack of conscious planning and the absence of detailed engineering drawings and specifications. Both of these are subject to simple correction and, therefore, are not particularly emphasized in this discussion. They appear to the writer to be details of administration which might be more promptly adjusted in a future program than they have been in the current one.

It should always be remembered, however, in any nation-wide program in a country such as the United States, with the multitude of local problems, legal jurisdictions, prejudices, financial variations in taxation and a hundred and one other ramifications of local procedure, that these cannot be easily ironed out or eliminated in six months.

Even assuming that a large public works program is a desirable anti-depression weapon, the problem still remains of superimposing such a program upon the widely diffused and highly ramified structure in this country, unless we are willing to assume the risks of extravagance, dissipation of funds and dishonesty of execution. We should remember that these programs cannot be carried out "in vacuo." The disabilities attached to them are not incidental to, but inherent in, their nature.

#### PERFORMANCE TO DATE

Although the facts presented briefly below have been the subject of some newspaper releases, it may be of interest to summarize briefly the accomplishments to date under the program of public works of the past year. Reference to table 1 will indicate that of a total of \$2,197,000,000 so far allotted to public works projects, \$1,369,000,000 has been granted to Federal projects and \$827,567,000 to non-Federal projects. Of these latter, somewhat over \$66,000,000 has gone to water works undertakings and approximately \$134,000,000 to sewerage systems.

Up to the close of business on May 15, checks totalling \$109,131,000 had been mailed out to cover requests for funds made by the recipients of non-Federal allotments. In addition to these funds, \$916,088,000 have been disbursed under Federal allotment by the various depart-

TABLE 1  
*Allotments by types of projects*  
(Federal Emergency Administration of Public Works)

TYPES OF PROJECTS	TOTAL	FEDERAL	NON-FEDERAL
Total.....	\$2,196,652,743	\$1,369,085,345	\$827,567,398
1. Streets and highways.....	\$505,936,784	\$465,488,849	\$40,447,935
2. Utilities (excluding power)...	215,868,312	15,101,080	200,767,232
a. Waterworks.....	66,463,972		66,463,972
b. Sewers.....	134,303,260		134,303,260
c. Other utilities.....	15,101,080	15,101,080	
3. Buildings.....	329,213,366	164,290,205	164,923,161
4. Engineering projects.....	587,206,092	380,591,947	206,614,145
a. Bridges and structures....	163,385,421		163,385,421
b. Reclamation, flood control and power.....	238,870,075	201,173,351	37,696,724
c. Water and navigation....	184,950,596	179,418,596	5,532,000
5. Vessels.....	262,946,474	262,946,474	
6. Aircraft and aviation.....	26,360,807	25,875,707	485,100
a. Aircraft.....	15,374,825	15,374,825	
b. Hangars.....	5,914,447	5,914,447	
c. Landing fields.....	3,195,888	2,710,788	485,100
d. Other aids.....	1,875,647	1,875,647	
7. Railroads.....	199,607,800		199,607,800
8. Miscellaneous.....	69,513,108	54,791,083	14,722,025
a. Ordnance and equipment.	18,277,286	18,277,286	
b. Nonstructural:			
1. Land purchase.....	616,088	616,088	
2. Survey and mapping..	3,354,258	3,354,258	
3. Plant, pest, and dis- ease control.....	21,207,427	21,207,427	
c. All other.....	26,058,049	11,336,024	14,722,025

ments of the Federal Government, making a total disbursement of \$1,025,219,000 out of the \$3,300,000,000 National Industrial Recovery appropriation. In this group, between 2,400 and 2,500 non-Federal allotments were made. Approximately 13,000 projects were Federal allotments.

In this connection, the experience of a small State such as that of Maryland is of interest. In the first week of January, 1934, less than one hundred persons were directly employed on non-Federal PWA work in Maryland. During the week of May 26, 1934, over two thousand were similarly employed, exclusive of railroads. The number is rapidly climbing and the results should be most apparent by the middle of August. To the State of Maryland, \$13,628,839 were allotted for Federal projects and \$50,192,766 for non-Federal projects, making a total of \$63,821,605. The full effect of these allotments to a State such as our own will not conceivably be felt for a number of months and the actual expenditures will be spread over more than a total of four years. Timeliness, therefore, the essence of the effectiveness of public works construction as an emergency measure, is obviously lacking in this as in all other parts of the United States.

#### CONCLUSIONS

If any conclusion may be drawn from the experiences up to date, they should be stated with a great deal of diffidence. The writer presents his conclusions not as definitive evidence, susceptible to quantitative proof, but only as the crystallizations of views developed during the past twelve months. They are as follows:

a. More accurate and less emotional estimates of the desirable and necessary public works enterprises in this country should be developed for the future.

b. It is by no means obvious that large scale public works expenditures during a depression period are a universal panacea, unless stripped of a number of the attendant evils which ordinarily accompany such expenditures. It is still not clear how additional spending, by agencies already financially embarrassed, is a logical step toward recovery. Furthermore the retardation effect upon private industrial recovery should not be taken too lightly.

c. If such expenditures are embarked upon, the distribution of funds should have some relationship to the areas most severely hurt by the depression. Financially healthy areas under most programs are those which are best able to carry on work and there it is least necessary.

"It may well be that in the emphasis on large public works expenditures, necessary permanent readjustments are being sacrificed for the sake of a temporary advantage."

## DIRECT PURCHASE OF MATERIALS FOR CONSTRUCTION CONTRACTS VS. PURCHASE THROUGH CONTRACTOR

BY PAUL HANSEN

*(Consulting Engineer, Chicago, Ill.)*

This is a subject that has received little if any consideration at technical meetings. It concerns owners, engineers, contractors, and manufacturers and distributors of materials and equipment. To date each engineer engaged in water works practice has developed his own policy. There is no evidence that bad practices have developed, but there has been, from time to time, more or less complaint on the part of producers of materials and equipment on the ground that they are not fairly treated by contractors or engineers. It is a subject that may be advantageously discussed by engineers, contractors, and producers of material and equipment as a means of developing practices that are as fair and equitable to all concerned as possible.

As an orderly approach, it may be well to outline the relative interests and objectives of the several parties concerned, namely the owner, the engineer, the contractor, and the producer and distributor of material and equipment.

### THE OWNER

The owner, who may be a municipality, water company, or individual, is interested in obtaining a good installation at minimum cost. He may lay down certain standards as to the substantiality of construction and decide policies with reference to architectural treatment, landscaping, parking, and the like. He will rely, in most cases, on his engineers with reference to technical matters and the arrangement of contracts, subject, of course, to legal check by attorneys.

### THE ENGINEER

It is the duty of the engineer to provide sound design, furnish plans and specifications in adequate detail and arrange contracts in such a way that works may be built at minimum cost consistent with fairness to contractors and to those who furnish materials and equipment.

In calling for bids on water works structures and appurtenances, engineers are actuated more or less by a desire to simplify the engineering supervision of the work in so far as this can be done without jeopardizing the interests of the owner. This has a tendency to reduce the number of separate contracts to a minimum so as to relieve the engineer of the extra work and trouble in dealing with a number of contractors and also relieve him of the difficulties of coördinating the work between various contractors.

Engineers also wish to keep cost at a minimum. This has a tendency to increase the number of contracts. He will, for example, arrange the contracts according to the character of the work so as to attract contractors who specialize in various classes of work, such as, for example, (a) excavation and earth work, (b) foundations and heavy construction of masonry, (c) building construction, (d) pipe work, (e) materials used in relatively large quantities such as pipe, cement, sand and gravel, etc. Some of these items may be further subdivided on very large undertakings, the limit being direct purchase of all material and equipment, thus reducing the function of contractors to that of furnishing labor, incidental materials and contractors' equipment for the classes of work in which the several contractors specialize.

Decisions in these matters are based upon the ideas and experiences of the engineer in which to some degree current practice has an influence. It is obvious that engineers will handle different jobs in different ways. A small job may, with justification, be turned over in its entirety to a single contractor. While under this arrangement the contractor may charge a profit on labor sub-contracts and on materials and equipment, the total of such profits will not be large, and will be offset by reduced cost of engineering supervision. On a large project it obviously becomes desirable to subdivide the work both as to character and as to size. Contracts that involve large sums of money will attract but a limited number of contractors and some division of the work is necessary to widen competition. On the other hand, it is not desirable to make the contracts too small, especially on public work, as this tends to attract too small and inexperienced contractors which may eventuate in poor results, delays, failures, and actually more cost. The numbers of contracts based on character of work will also be increased whenever the magnitude of any special work is sufficient to warrant a direct contract. No fixed rules can be laid down for arranging contracts on any project or on

any class of projects. The engineer must exercise judgment in every case.

Direct bids on equipment and machinery are usually preferred by engineers as it promotes competition and gives them greater latitude of choice as compared with receiving bids through contractors. The engineer also prefers award of separate contracts on important equipment and machinery because this brings the engineer into more direct and satisfactory relation to the manufacturer with reference to both installation and subsequent servicing.

On relatively small work direct bidding on some or all material and equipment may become too cumbersome, but substantially the same results may be obtained by requiring bidders to submit figures on, say, half a dozen different makes that conform with the specifications as written. This permits in many cases an adequate latitude of choice on the part of the owner and engineer but places in the hands of the bidder some restrictive power over the producers and distributors.

A problem confronts the engineer when equipment or machinery of substantially equal suitability requires radically different arrangement and structural design for its accommodation, thus making it difficult to make comparisons of cost without also making alternative designs. When possible differences in cost warrant, or when the encouragement of more active competition promises substantial savings it is in the interest of the owner to prepare alternative designs even though added engineering expense is involved.

Such a situation may be met in part by requiring general contractors to submit with their bids, prices of a number of makes of equipment. After bids are received alternative designs to accommodate different types of equipment may be prepared merely in sufficient detail to reasonably satisfy the engineer and owner that equipment to fit the plans as drawn is reasonably satisfactory and economical. This procedure involves loss of time in awarding contracts which is unfair to the general contractors who have deposited certified checks. If, however, it is found that some other equipment is clearly preferable in point of cost then the engineer must still find some way to finance cost of redesign.

As contractors are not interested, theoretically at any rate, in making a profit on equipment and machinery, it is permissible, at least with respect to some equipment to require them to include in their bid an arbitrary figure designated by the engineer for equipment and machinery and to add or deduct from this figure the difference

between the arbitrary bid price and the actual price according to whether the latter is above or below the bid price, provided items for erection are properly included. This arrangement has the merit of not delaying a decision on the award of general contracts, but is difficult to apply where different equipment requires different structural design.

A variation of the above arrangement would be to request manufacturers to submit to the engineers under seal, prices available to contractors and it should be understood that decisions will be made on the basis of these prices and no others. This arrangement has the advantage of permitting broad competition among manufacturers and avoiding possible confusion that may result should a manufacturer give different prices to different contractors or should a bidder accidentally misquote a manufacturer. This arrangement in effect involves informal direct bidding by manufacturers and the question may be raised as to why we should not go a short step further and have formal direct bidding.

The objectives throughout should be, (a) to avoid comparison of general bids on the basis of equipment and machinery of different makes and types, (b) to give the engineer adequate latitude of selection and (c) to have all prices on equipment and machinery in hand at time of bidding so that contractors cannot shop about among manufacturers for price concessions after contracts are awarded. This last mentioned activity on the part of contractors results in waste of the time of engineers and manufacturers and places an unfair pressure on manufacturers to cut prices already quoted in fair competition.

#### THE CONTRACTOR

Theoretically, as above suggested, contractors should be indifferent to whether the material and equipment is purchased directly or through them. They are primarily concerned in obtaining a fair return for their management of labor and use of construction equipment and furnishing incidental material and supplies. Practically, however, they generally prefer purchase of material, equipment and machinery through them, first because it gives them better control over the delivery of such material and hence better control over the coördination of their work, and second, it gives them an opportunity to make a little additional profit, not so much through adding a percentage to the cost of the material and equipment, but

rather by shopping among the people who can furnish material and equipment after the contract is awarded.

Where standard material and equipment is involved or material and equipment which can be accurately measured as to suitability and equality, the engineer has little preference as to whether the material is purchased directly or through the contractor. He is more inclined to lean toward purchase through the contractor in order to relieve himself of a certain amount of detail. The producer and distributor of material and equipment, however, is somewhat seriously affected, especially in times of depression when everybody is looking for business. At any rate, the producer and distributor are put at a distinct disadvantage as compared with the opportunity of submitting sealed competitive bids which are final and which must be accepted or rejected.

As it is hopelessly impossible on small jobs and jobs of moderate size to purchase all material and equipment directly, some purchases must be made through the contractor. It is perhaps advisable, however, for the engineer to lean toward the direct purchase of the more important materials and equipment. For example, pumping equipment may be always purchased directly; also various meters and special equipment may be purchased directly with advantage to the owner and with greater fairness to the producers and distributors of such equipment. Valves and sluice gates are on the border line and cannot often be conveniently purchased directly.

#### PRODUCERS AND DISTRIBUTORS OF EQUIPMENT

The interests of producers and distributors of materials and equipment have already been reflected in the foregoing discussion. In general, they are interested in obtaining at least fair prices for their individual products. To this end they fortify themselves as much as possible with patent claims, good quality, meritorious elements of design, and talking points which may or may not have merit. In general, it would be to their interest to bid directly on their products especially if they happen to be in a position where through patent rights, popularity or other reason they are able to maintain a good price. It is more or less common among producers and distributors to allow contractors a discount so that when selling through contractors they often lose somewhat of their profit. Even on standard materials the quality of which can be closely evaluated through suitable tests such as cement, sand and gravel, cast iron pipe, brick,

stone, structural steel, etc., there is still an advantage to the producer in selling directly in order to avoid the shopping practices of some contractors. Many contractors maintain an ethical attitude in the matter of purchase from producers of materials and equipment. They obtain a price before bidding with the understanding that this price will be paid and with the understanding that the material will be purchased from a given concern subject to the approval of the engineers. Producers and distributors of material and equipment on their part do what they can to force contractors into this attitude by refusing to give certain contractors a final figure or any figure at all on their products unless the contractor agrees in advance to give them the business, assuming that the contractor is successful in getting the contract.

All in all, the situation as between the producers and distributors on the one hand and contractors on the other is not satisfactory. Much improvement can be brought about perhaps by the intermediation of the engineers. The engineers on their part are limited in what they can do because of the impracticability of buying all materials and equipment directly, especially on small jobs.

It is difficult to formulate a fixed practice that will be fair and equitable to all concerned on all kinds of jobs. However, decisions with reference to direct purchase of material for construction contracts vs. purchase through contractors may be more equitably made in light of a freer discussion than has hitherto been available and in this discussion all parties concerned should take part.

### DISCUSSION

L. R. Howson (Consulting Engineer, Chicago, Ill.): A discussion of this paper may be somewhat simplified by subdividing the expenditures in the ordinary water works between:

1. Structures and types of construction requiring the assembling, coordinating and supervision of a large amount of diversified labor and materials, and
2. Materials and manufactured products which can be delivered directly to the owner ready for assembly or installation.

In the first class we may place structures, including wells, buildings and reservoirs, which, in the average water works, account for from 10 to 15 percent of the total investment; pipe laying, averaging approximately 25 percent, and services, averaging approximately 10 percent of the total investment.

In the second class may be grouped such items as cast iron pipe, ordinarily involving approximately 25 percent of the total investment, valves 2, hydrants 3, pumping equipment 10 to 15, and meters 5 to 7 percent of the total investment.

It is substantially uniform practice in water works construction at the present time for all structures to be built by contract, with the contractors furnishing all materials under specifications drawn by the engineer. There are so many sub-contractors involved with the operations of each inter-dependent upon others, so many and varied types of materials to be purchased and delivered when needed, so much chance for divided responsibility that to do otherwise would make it practically impossible to coördinate the various operations. Delays, increased costs, possible litigation and other incidental trouble would be difficult to avoid. On the other hand, it is entirely practicable, and the adopted policy in the majority of cases, to purchase direct major equipment and distribution system materials, including pipe, valves, hydrants, and meters, and to contract for their installation. These materials are not perishable and are easily stored so that if the time of their arrival is not entirely coördinated with the progress of construction, no loss results.

Direct purchase of distribution system materials, pumping and filtration equipment is desirable from the following viewpoints:

1. *Saving in carrying charges*—If purchased through a contractor, a carrying charge is necessarily added, usually in the amount of 5 to 10 percent. When applied to approximately 50 percent of the investment this becomes a material item.
2. *Possibility of selecting lowest and best bids*—It would be rare indeed for a general contractor to assemble in one proposal the lowest and best bids on each of the several items. Only direct purchase guarantees this advantage.
3. *Broadest competition*—General contractors in submitting proposals on equipment, have not the facilities, inclination or ability to analyze the merits of equipment they offer, which they must purchase from manufacturers. They are principally interested in being able to quote a composite price low enough to get the job.
4. *Responsibility*—When equipment is purchased through a general contractor, the purchaser must depend upon the manufacturer rather than the general contractor for his future service, and guaranty of the equipment purchased.
5. *Qualified bidders*—What is desired is the fullest competition from all manufacturers specializing and experienced in the design and manufacture of special equipment. That competition can only be secured by direct quotation from the manufacturer to the purchaser.

It has been the speaker's experience that some additional effort and expense is justified on the part of the engineer in order that he may so subdivide the total work as to secure bids from qualified experts on each phase of the work rather than a single proposal covering all of the work, including the furnishing of materials amounting to approximately 50 percent of the total with which the general contractor has no familiarity and all too frequently no responsibility. To illustrate, there can be no more discouraging experience for an engineer than to have a general contractor attempt to purchase, furnish and install filtration equipment with ordinary plumbers and pipefitters.

It is practically impossible to make a satisfactory selection of pumping equipment from bids submitted by a general contractor to whom such questions as velocity head, efficiency, power consumption, etc., are so much Greek.

It has been the speaker's observation that most of the difficulties that have arisen through the direct purchase of equipment have resulted from the comparison of bids on equipment of different types, such as cross-compound steam pumping equipment vs. motor driven equipment, or turbo-centrifugal equipment, and in water softening plants as between equipment adapted for installation in square or rectangular basins. This is sometimes a difficult matter; however, in general, it is believed that the engineer should make an investigation prior to the preparation of plans and specifications to determine what type of equipment is best suited to the particular service requirements, and then to prepare his detailed plans and specifications on that basis. Alternates may be presented, but if the preliminary investigation has been sufficiently comprehensive, it is not likely that the situation will be changed when the bids are canvassed. The taking of too many alternates frequently results in dissatisfaction among bidders and confusion of the owners, as well as requires expenditures for figuring by manufacturers, who possibly have a very small chance of being successful in getting the work.

## NEW QUESTIONS OF LAW AND POLICY IN THE MAKING OF RATES FOR WATER SERVICE

BY WILLIAM L. RANSOM

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The events of the past three years, and perhaps chiefly the past year, have brought us face to face with new questions of law and policy in the making of rates for service. As we survey the American scene, we note appearances of change in the whole relationship of the agencies of public service to their customers and to the government. In their emergent setting, these questions may have appeared to be dominated more by public policy than by rules of law as we have known law; but emergencies pass and human nature seeks return to accustomed paths. Experience reminds us, however, that mature considerations of public policy have often crystallized into law and into concepts of constitutional interpretation. So it may be in order to begin to inventory and take stock of some of these developments, and to try to see where they may lead and where they have left us.

May I first suggest for your contemplation the question whether a new consideration for the investor, and a new concept as to who is the investor, may not be soon at hand, in the making of rates for public service. Are we not beginning to realize that the investor in utility properties is not merely the man who owns bonds or stocks in enterprises that are privately owned? The ever-increasing burden of taxes and public debts reminds us that the taxpayer is an investor in utility enterprises, when the government supplies the financing of such projects. If you create conditions under which men will not invest voluntarily, then you must take the required capital from them in taxes or place the burden on their backs in the form of public debt. Today the situation all around us is that, in addition to the vast number of investors in the bonds and stocks of the privately operated enterprises, we are becoming a Nation of involuntary investors in enterprises created or financed by those who possess the power to levy taxes and create public debt.

The money that is taken from taxpayers or derived from bond issues by the government is none the less an investment of capital in the utility enterprises thereby brought into being and financed. For such purposes, a staggering percentage of the total National income is now taken; and the borrowings impose a still large burden of debt and fixed charges for the future. Under such circumstances, what of the taxpayer-investor, the involuntary investor? This new class of investors comprises practically all of our people. Has not the taxpayer-investor in the public projects, no less than the investor in the privately operated projects, an interest and a right to insist upon competent, businesslike and non-political management, and upon operations and rates which will carry fully the fixed charges on these investments and amortize the public debts by which they were created? I can see no way out, no avenue to the liquidation of the great volume of public debt now being created, except through resolute insistence that the new enterprises of government shall pay their own way and pay off their own debts, which in effect means rates reasonable and adequate for such purposes, including a return upon the capital involuntarily contributed through its taxing power.

We who have responsibilities in connection with the operation and management of utility enterprises may have to face an early accounting to both types of investors. Fundamentally, the taxpayer investor and the private investor are pretty much in the same boat; the incident of the mode of ownership may become less consequential. Fair consideration for the taxpayer who has been made an involuntary investor in governmental projects may require that the bases of rate-making for these projects be soon reviewed and revised. I have long felt that the bases of rate-making for public and private plants should become more nearly alike. The rate structures of the public plants should be freed of political considerations and should be made economically sound and sufficient. On the other hand, the rate of structures of the private plants could learn much from those of some public plants, in the inducement of additional uses of the service and in conformance to the long-run public interest. Better forms of rates, and the abandonment of old and now unsuitable forms of rates, are needed everywhere in the utility industries, however owned. But I submit particularly for your consideration these questions: What consideration may soon be demanded by and for the taxpayer-investor? Fundamentally, is he not in about the same position as the involuntary investor? May not both types of investors soon demand a deal which is square as well as new?

Next may I comment briefly upon a recent statutory change which is of interest in connection with the machinery of rate-making under public regulation and judicial review. The present Congress has passed and the President has signed the Johnson bill, which is commonly referred to as excluding public utilities from the Federal Courts, for the redress of grievances against rates fixed by State Commissions or municipal authorities. This is not the time or place to discuss the merits or the constitutionality of this abridgment of the historic jurisdiction of our Federal tribunals. There is always a grave danger to free government, it seems to me, when any particular class of corporations or persons is singled out and denied equal access to the Federal tribunals for enforcement of the traditional guarantees of the Federal Constitution. If such a thing may be done to one class of corporations or persons today, the rights of others may be similarly curtailed tomorrow.

My present purpose, however, is to denote the nature and the limits of the attempted change. The new legislation deprives the United States District Courts of jurisdiction, in first instance, of actions brought by utility corporations against rate orders of State Commissions or municipal governments, where repugnance of the order to the Constitution is claimed, and where such order "does not interfere with interstate commerce, and has been made after reasonable notice and hearing, and *where a plain, speedy and efficient* remedy may be had at law or in equity in the Courts of such State." This is no absolute and utter exclusion of the utilities from the Federal Courts in first instance. It applies only where the processes of judicial review in the State Courts are "plain, speedy and efficient." It does not apply where the rate order has been made without reasonable notice and due hearing, as is sometimes attempted in fixing so-called temporary or emergency rates, and it does not apply where the State Court calendars are congested and the processes of review are dilatory, but only when the procedures of State Court review are "plain, speedy and efficient," thereby enabling the Federal questions of confiscation to be taken promptly to the United States Supreme Court from the highest Court of law in the State, where the State Court's determination is adverse to the Company.

Many and unprecedented questions of law and policy now press for solution, in relation to the regulated public utilities. These problems arise in the field of rate-making, management, valuation, return, and the activities of intervening governmental agencies. It would

be premature for me to try to review them now, in remarks before this meeting.

The water supply business developed in America as a high function of public service, conducted as essentially a local concern. The incident whether the ownership was public or private has not altered the essentially local character of water supply service. Its enterprises have been primarily accountable to their local communities; there was and could be no far-flung interconnection.

Next came the development of State regulation of rates, accounts, service and securities. This introduced new complications and new costs, for both the public and private plants, and has at times jeopardized the primary local responsibility to the community, its wishes and needs, and its standards of fair play.

But even the rise of State regulation by Commission did not challenge or disturb the status of the water companies as public utilities devoting private capital to public service. The private property was subject to the protection of constitutional limitations upon governmental action. Regulation must be reasonable, could not confiscate, could not destroy. Billions of dollars were in good faith invested in public utilities on that basis. Now those investments have been in large part impaired, and may soon be destroyed, by governmental action which is financed with monies taken from private capital by taxation and is claimed to be subject to no such constitutional restrictions or limitations.

## RECENT TENDENCIES IN RELATION TO VALUATION OF WATER RIGHTS

BY ROBERT E. HORTON

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It happens that twenty-five years ago two publications appeared dealing with the valuation of riparian rights and the determination of diversion damages. The first paper, which was by the present author,<sup>1</sup> dealt with engineering practice in water power valuation as of that date. The second publication referred to was the report of the Committee of the New England Water Works Association on Data Relating to Awards for Water and Water Power Diversion.<sup>2</sup> It contained data regarding prices paid and awards made in the acquisition of riparian rights and diversion damages for water supply purposes in over two hundred cases, representative of conditions throughout a period of about thirty years prior to the date of the report.

The present paper is mainly devoted to a consideration of engineering and economic changes in water power practice during the subsequent quarter of a century in relation to their effect on water power valuation and the cost of acquisition of diversion rights. The general principles and practice of water rights valuation were set forth in the author's preceding paper above referred to and will not be repeated except insofar as necessary to make the present paper reasonably self-contained and to provide a background for discussion of the effect of changes in conditions in the subsequent period.

### THE NEW ENGLAND COMMITTEE REPORT

While this report appeared in 1910, the data it contains cover a period running back sometimes to the 1870's, long prior to the advent of hydro-electric power development and transmission. Nearly all the purchases, sales and awards reported relate to conditions where

<sup>1</sup> Horton, Robert E. The Valuation of Water Power and the Estimation of Stream Diversion Damages. Proc. Am. W. W. Assoc., 1909, pp. 1-25.

<sup>2</sup> Jour. New England W. W. Assoc., 24: 1, March, 1910.

water power development was on the individual mill basis or under conditions quite different from those now existing, where general electric energy distribution prevails. The work of the committee was well done and the data contained in their report have often been used and still are used as a basis for valuation of water rights in condemnation proceedings and rate cases. In view of this situation and because of the remoteness in point of time of the data contained in the New England Committee's report, attention will be given to the question of the applicability of these data under present-day conditions.

The New England Committee prices were expressed in terms of dollars per square mile of diversion per foot of fall on the riparian property against which the diversion took place. The data can readily be converted into prices per horse power, using the rule adopted by the Committee to the effect that, in New England, the runoff from 1 square mile, as usually developed, will produce 0.1 h.p. It has not always been recognized that prices expressed in units of cost of diversion rights per square mile per foot of fall cannot be correctly applied without correction in localities or to projects where the available power per square mile-foot differs from 0.1 h.p.

Consider, for example, a diversion of the runoff from 100 square miles against 100 feet head. This corresponds to 10,000 square mile-feet. If the diversion happens to be in a locality of high runoff or the stream is so regulated that practically its entire runoff can be utilized, it may be possible to produce, for example, 0.20 or 0.25 h.p. per square mile-foot. The direct application of unit prices based on the number of square mile-feet for New England conditions would lead to a serious under-estimate of the value of the riparian rights. If data from the New England report are to be used in such a case the better procedure is to convert the unit prices into prices per horse power and apply the result to the number of horse power affected by the diversion.

The report of the New England Committee contained data of awards and accompanying conditions in cases where rights to divert water had been acquired either by purchase or condemnation as against both developed and undeveloped power sites. In some cases the entire rights were acquired. In other cases the diversion was partial or incomplete and consequential damages were involved. The committee gave in its report average prices paid per square mile-foot: (a) as against developed privileges; (b) as against unde-

veloped, unused or abandoned privileges. In arriving at these averages no distinction was made between the taking of the entire properties, where no consequential damages were involved, and partial diversions, where a part of the cost may have been and generally was payment for secondary or consequential damages. The latter includes cases of undeveloped powers where only part of the stream was diverted above the power site, and also cases of developed powers where the owner was left with the dam and power plant, but with the stream flow diminished or wholly diverted.

No compilation of purchase prices and awards for diversion damages has been published since 1910, although it seems desirable that this should be done. The average prices reported by the New England Committee have sometimes been applied directly to individual cases. This method has little justification. Few particular cases correspond to average conditions. Furthermore, as above noted, differences in stream yield, regulated flow and differences in conditions as to consequential damages should be taken into account in each individual case to which such data are applied.

A better method of application of these and other similar data is in conjunction with what, for want of any other name, the author has designated as the "real-estate method" of valuation of riparian rights as distinguished from what may be designated as purely calculated valuations.

#### I. RECENT CHANGES IN THE ART AND ECONOMICS OF POWER PRODUCTION

As a basis for discussion of recent tendencies in water power valuation and the determination of diversion damages it is necessary to outline briefly the changes in practice and economics of power production subsequent to the period covered by the two publications previously referred to.

Before the advent of general electrical distribution of energy and for conditions pertaining in most but not all of the cases reported by the New England Committee, each water power was used to supply mechanical energy directly to a manufacturing plant or factory. As a rule the power was developed without storage regulation and the power development was of the type known as a "run-of-the-stream" plant.

The available power was often deficient during part of the time, whereas the manufacturing plant generally required more or less

continuous power. An auxiliary steam plant was usually provided. The hydraulic turbines were of efficiencies rarely exceeding 80 percent and much power was lost in gearing and transmission. Steam power was produced by reciprocating engines, often non-condensing, and the exhaust steam was frequently used for heating or in manufacturing purposes. Coal consumption per unit of energy output was high, especially in plants operating 10 hours per day and requiring the use of considerable quantities of coal for banking of boiler fires during night hours.

The water power developments were usually under low heads; their operation was often interfered with by ice and back-water, as well as by low stream flow. The low grade and irregularity of the water power was, however, more or less offset by the high cost and inefficiency of steam power generation. As a result largely of these conditions, the prices paid for diversion rights under the old regime were often of the same order as those prevailing today under a widely different program of power development and use.

The conditions described continued during the early period of hydro-electric development or generally from 1900 to 1910. Each community then had its own local electric company or system, not connected with adjacent plants. If hydro power was used it was usually produced by a run-of-the-stream plant or plants and an auxiliary steam plant was maintained to provide for deficiency in hydro plant output and to meet demands exceeding the available hydro power. The hydro power could not be relied upon to meet energy demands exceeding the available output from the minimum flow of the stream and steam plant capacity must be maintained often nearly equal to the maximum energy demand. As a rule some, at least, of the boilers in the steam plant must be kept under fire continuously. Part of the steam plant was used only at infrequent intervals and produced little revenue, although the fixed charges ran continuously throughout the year.

Under these conditions the combination of steam and hydro power was costly and unsatisfactory for the production of electric energy for public distribution. Many of the earlier large hydro-electric developments passed through receiverships—in fact, hydro plants of the early run-of-the-stream type were often less satisfactory for public utility service than for operation by private mills and factories, owing in part to the insistence of the customers' demands. Deficiencies in energy supply could not be tolerated to anything like

the same extent as in a private manufacturing plant where, in many instances, it was regular practice to shut the plant down altogether for repairs during the season of extremely low water flow in the summer.

During about the same period the use of the steam turbine became general and this was followed by improvements in boilers, permitting the use of higher steam pressures, greater steam economy and lower power cost. It was soon recognized that energy of the type demanded for public service could often be produced more cheaply and reliably in a large central steam plant than by a run-of-the-stream hydro plant with steam auxiliary.

In the meantime there was some improvement and reduction in cost of hydro power production. Turbine efficiencies were increased from about 80 percent up to a maximum of about 94 percent; much larger individual energy-producing units were introduced, greatly reducing the cost per unit of capacity; turbo-generators of the vertical type, both steam and hydro, were developed, with the moving weight suspended from a roller bearing at the top of the unit, thus increasing the overall efficiency of the unit.

Even with these improvements in hydro power, the steam generating station usually had the advantage over the hydro plant of the run-of-the-stream type and the statement was frequently made, without qualification, that hydro power could not compete with steam power and consequently that water rights or riparian rights had no value whatever for purposes of power production. That idea is not uncommon at the present time.

Going on with the history, there was in general keen competition between utility companies serving adjacent regions. There were those engaged in power production who soon recognized that it was really the high cost of auxiliary steam that made the run-of-the-stream—steam auxiliary combination costly and unsatisfactory. Then began the more frequent development of hydro power in conjunction with pondage and storage, providing regulated stream flow and making it possible to produce firm or continuously available hydro power and also to take care of maximum energy demands by hydro power alone, at less cost than by steam power alone. This led to the use of hydro power plants with storage and pondage, operated primarily to produce the irregular or peak energy demand, the base or continuous power in the same system being produced by steam plants operating at high load factors and hence at minimum

cost per kilowatt-hour. Each type of plant can often produce its type of energy at less cost than the same type of energy can be produced in the other plant.

It is not to be inferred that run-of-the-stream hydro plants are obsolete or always inefficient. Their operation as individual plants for electrical energy production is one thing, their operation in conjunction with other plants, steam or hydro, in a large distributing system, is quite another thing. In the latter case and especially for run-of-the-stream hydro plants on large rivers, such as the Hudson or Susquehanna, a run-of-the-stream hydro plant may be highly economical and cheaper than any other method of producing the type of energy for which it is used. Often such plants on large rivers are used to produce energy intermediate between the base load and the higher peak energy demands, the limits of operation depending upon the regularity of stream flow and the diurnal pondage available, as well as on many other things. Individual hydro plants for operation of mills and factories also continue in use, particularly in the case of certain classes of industries.

#### RELATION OF TYPE OF ENERGY PRODUCED TO VALUE OF WATER POWER

To begin with, certain terms should be defined.

*Base energy* is that part of the load demand on the plant which is practically continuous, or which is continuous night and day throughout, say, 99 percent of the time.

*Load factor* is the ratio of the average rate of energy production to the maximum rate. For example, a plant which produces base energy alone, at a constant rate, operates at 100 percent load factor.

*Capacity factor* is the ratio of the average rate of energy production to the maximum possible rate or to the plant capacity. In general this is less than the load factor since, as a rule, a plant is seldom operated at its maximum or full capacity. For example, a plant having a capacity of 10,000 kw., producing an average load of 4,000 kw., and a maximum load of 8,000 kw., would operate at a load factor of 50 percent and at a capacity factor of 40 percent.

*Peak load* is the highest rate of energy production required to meet the load demand on a given plant or system.

*Peak demand.* This is the capacity required to meet the load demand in excess of any specified amount, or measured from the peak down to any given point on the load curve, as, for example,

the difference between the peak load and either the average load or the base load.

**Peak energy demand.** This is the amount of energy in horse power-hours or kilowatt-hours required to meet the peak demand, measured from the peak load down to any specified point, as, for example, the highest 20 percent of demand.

Figure 1 shows two daily load curves for a fairly large hydro-electric distribution system, one for summer, the other for winter conditions. In the latter the peak is more accentuated owing to the

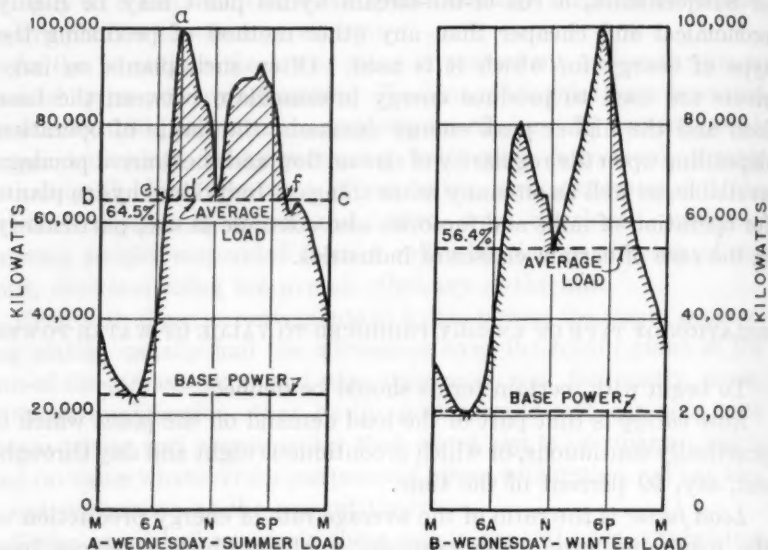


FIG. 1. DAILY LOAD CURVES FOR A LARGE ELECTRIC ENERGY DISTRIBUTION SYSTEM

superposing of commercial and lighting demands in the late afternoon. On figure 1-A the point *a* represents the peak load, the line *bc* the average load, the distance *ad* measures the peak demand in excess of the average demand, and the shaded area *aef* represents the peak energy demand in excess of the average demand.

In figure 2 a daily load curve for another system is converted over into what is called a load duration curve, showing the duration in hours per day of energy demands in excess of different demand rates. The duration of the higher rates of load demand are surprisingly small. For example, as shown by the point *M*, the highest 20 per-

cent of the load demand has a duration of but 0.6-hour per day. The relation of peak load demand to energy requirement is more clearly shown by figure 3, which is a peak energy demand curve derived from the same data, and shows on the horizontal scale the proportion of the total energy output which is required to meet the part of the load measured from the peak down to any given point on the load scale. As shown by the point *N*, the energy required

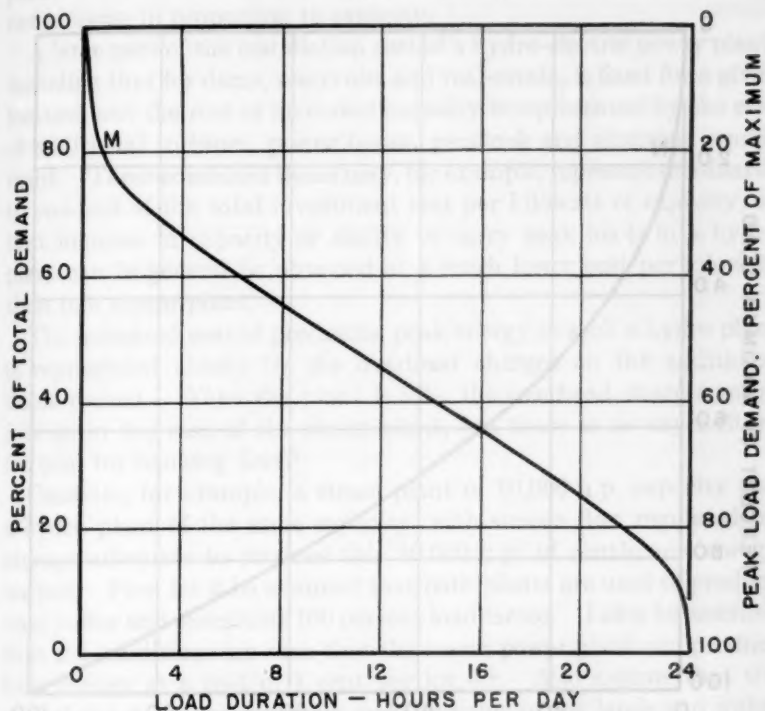


FIG. 2. DAILY LOAD DURATION CURVE

to meet the highest 20 percent of the load demand is but 2 percent of the total energy demand.

Figures 2 and 3 serve to illustrate the fact that a considerable part of the plant capacity, whether steam or hydro, required to meet the demands of public utility service, can operate productively only a small part of the time. For example, in the illustration used, 20 percent of the capacity of the plant would operate on an average but 2.5 percent of the time and would produce only 2 percent of

the energy output. The investment cost per unit of this capacity is, for a steam plant, substantially the same as for the more productive units operating at higher load factors. Not only must the overhead charges be carried continuously on the part of the plant which operates only a small part of the time, but, as a rule, the boilers must be kept continuously under steam, so that the coal consumption per unit of energy output is greatly increased as compared with opera-

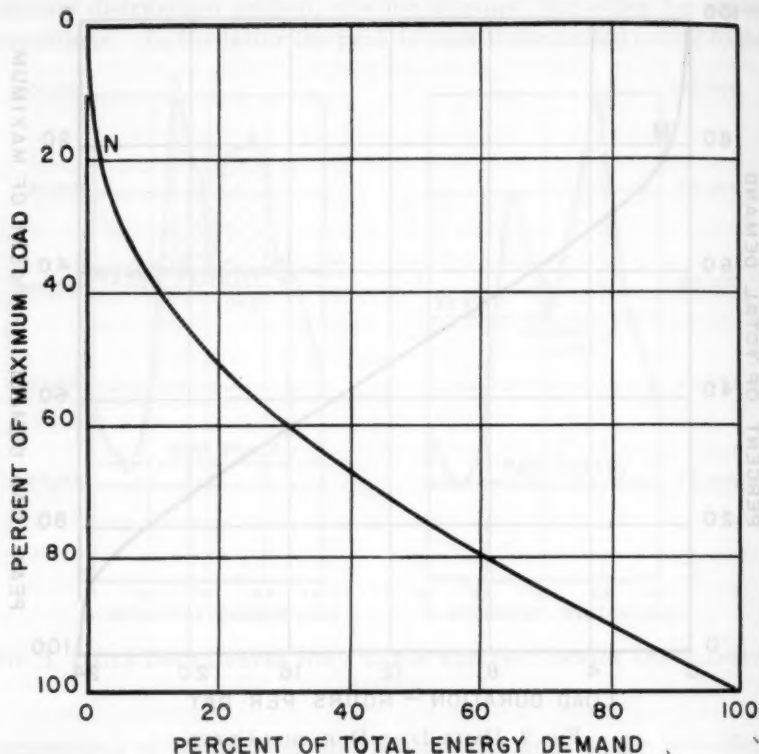


FIG. 3. DAILY PEAK ENERGY DEMAND CURVE

tion at a higher load factor. It follows at once that the cost of energy output in a steam plant increases rapidly as the load factor decreases. Assume, for example, that part of a plant operates 20 percent of the time, on an average; another portion operates 100 percent of the time. The fixed charges per unit of capacity are the same in both cases and hence the overhead expense per unit of energy actually produced and sold is five times as great for that part of the

plant used for peak load production and operating on an average of 20 percent of the time as for that part of the plant producing base load at 100 percent load factor.

In case of a hydro plant the situation is somewhat different. In case of hydro generating units operating part time only, there is no charge corresponding to the cost of coal for banking fires in a steam plant. The cost of increasing the capacity of a hydro plant does not increase in proportion to capacity.

A large part of the installation cost of a hydro-electric power plant, including that for dams, reservoirs and real-estate, is fixed for a given location and the cost of increased capacity is represented by the cost of additional turbines, power house, penstock and electrical equipment. These combined items may, for example, represent one-fourth to one-half of the total investment cost per kilowatt of capacity, so that increase in capacity or ability to carry peak loads in a hydro plant can in general be obtained at a much lower cost per kilowatt than in a steam plant.

The increased cost of producing peak energy in such a hydro plant is represented chiefly by the overhead charges on the additional items named. When the plant is idle, the overhead charges go on just as in the case of the steam plant, but there is no expenditure for coal for banking fires.<sup>3</sup>

Consider, for example, a steam plant of 10,000 h.p. capacity and a hydro plant of the same capacity, with stream flow regulated by storage adequate to produce this 10,000 h.p. of continuous energy output. First let it be assumed that both plants are used to produce base power and operate at 100 percent load factor. Let it be assumed that the conditions are such that the steam power plant can produce base energy at a cost of  $\frac{1}{2}$  cent per kw.-hr. Also assume that the cost of the dam and reservoirs and the value of the lands and water rights on the basis of 10,000 h.p. installation amounts to \$300.00 per h.p. and the cost of power station and equipment \$40.00 per h.p. Taking fixed charges against the dam, reservoirs and lands and water rights at 10 percent, this amounts to \$30.00 per year per horse power of capacity. Taking fixed charges, including depreciation on plant and equipment at 12 percent amounts to \$4.80 per year per horse power of capacity. Allow for miscellaneous and station expenses \$3.00 per year per horse power of capacity under full-time operation.

<sup>3</sup> Horton, Robert E. Water diversion between drainage basins, Jour. Am. W. W. Assoc., 24: 11, November, 1932, p. 1641.

The total production cost of base power by the hydro plant is \$37.80 per year per horse power when producing base power at 100 percent load factor. This is equivalent to 0.575 cent per kw.-hr. for production of base power in the hydro plant or somewhat more than the cost of steam power.

Next assume that each plant is increased in capacity 100 percent and, while producing the same output as before, the excess capacity is used for production of peak demand energy, amounting to 20 percent of the average load. The additional plant will operate on a 20 percent capacity factor in each case. For the steam plant, when producing energy to meet peak load demands, fixed charges per kilowatt-hour of output will be multiplied five times. The coal consumption and cost per kilowatt-hour will also be increased because

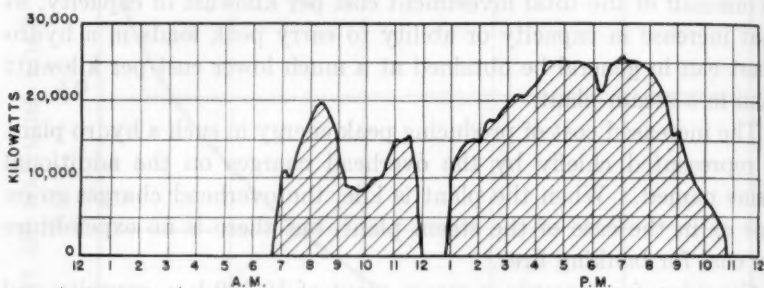


FIG. 4. DIURNAL LOAD CURVE. HYDRO PLANT WITH STORAGE AND PONDAGE CARRYING DAY PEAK LOADS

of the banking of fires during non-operating hours. Without going into details, computations of the energy costs for the steam plant under these conditions indicate that the cost would be in the neighborhood of 1.6 cents per kw.-hr. In case of the increased hydro plant capacity used for peak energy production, one-fifth of the flow is utilized and therefore one-fifth of the cost of the dam and reservoirs may, for purpose of illustration, be charged against peak energy production. This amounts to \$60.00 per horse power of capacity or—taking fixed charges on this part of the plant at 10 percent—\$6.00 per year per horse power of capacity. Fixed charges on the additional power station and equipment at \$40.00 per horse power and at 12 percent amount to \$4.80 per year per horse power of capacity. Miscellaneous and station expense may be taken at \$1.20 per year per horse power of capacity for part time operation. Total, \$12.00

per year per horse power of capacity. The new plant operates at 20 percent capacity factor, so that the annual cost of power production is \$60.00 per horse power-year. This is equivalent to 0.914 cent per kw.-hr. or a little more than half the cost of the production

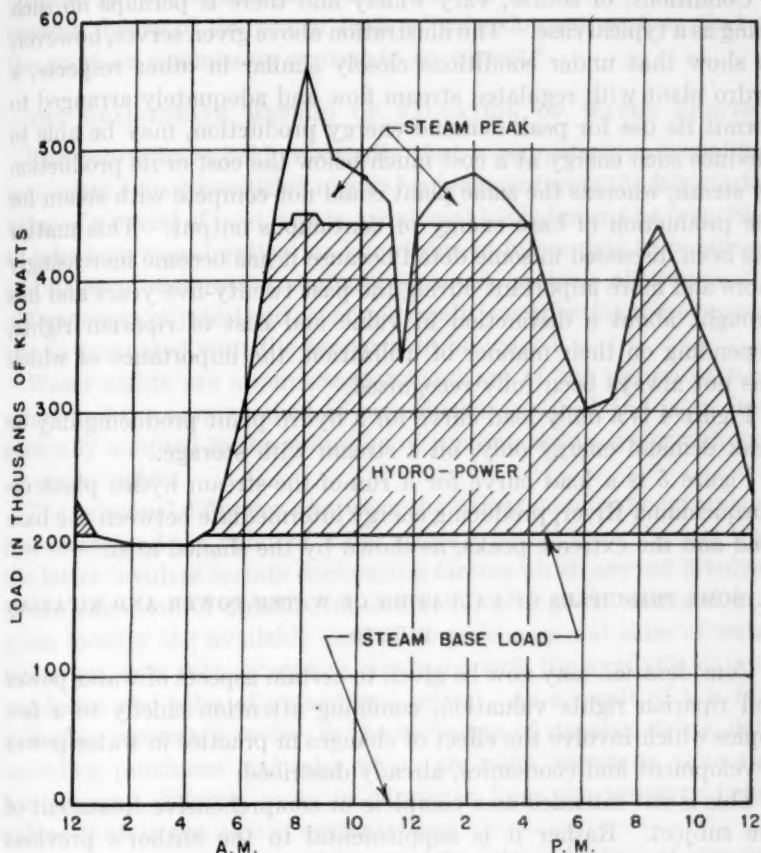


FIG. 5. DAILY LOAD CURVE. LARGE RUN-OF-THE-STREAM HYDRO PLANT CARRYING INTERMEDIATE LOAD DEMAND

of the same amount and grade of power for peak demand service in the steam plant.

Of course, this means that the value of the part of the stream flow or water rights, used and usable for peak demand energy production in the hydro plant, is much greater per horse power than the remaining stream flow. It should also be pointed out that in the illustra-

tion used, the relatively low cost of peak energy production by hydro power as compared with steam is partly due to the fact that it is assumed that the dam and reservoir have already been built, and the greater part of their cost is charged to the remaining power output.

Conditions, of course, vary widely and there is perhaps no such thing as a typical case. The illustration above given serves, however, to show that under conditions closely similar in other respects, a hydro plant with regulated stream flow and adequately arranged to permit its use for peak demand energy production, may be able to produce such energy at a cost much below the cost of its production by steam, whereas the same plant could not compete with steam for the production of base energy or continuous output. This matter has been discussed in some detail because it has become increasingly more and more important during the past twenty-five years and has brought about a distinction in value and cost of riparian rights, depending on their manner of utilization, the importance of which has not always been fully recognized.

Figure 4 is a daily load curve for a hydro plant producing day or peak demand energy only, on a stream with storage.

Figure 5 is a load curve for a run-of-the-stream hydro plant on Susquehanna River, producing energy intermediate between the base load and the extreme peaks, as shown by the shaded area.

## II. SOME PRINCIPLES OF VALUATION OF WATER POWER AND RIPARIAN RIGHTS

Consideration may now be given to certain aspects of water power and riparian rights valuation, confining attention chiefly to a few topics which involve the effect of changes in practice in water power development and economics, already described.

This is not intended as a complete or comprehensive treatment of the subject. Rather it is supplemental to the author's previous paper and other similar discussions. The author is not a lawyer and the subject is treated only from an engineering and practical viewpoint. Under these conditions it has not been deemed necessary except in a few cases to cite decisions of the courts. The author believes that an engineer engaged in water rights valuation for use in court should have some knowledge of the elementary legal principles governing riparian rights and water rights valuation, and that he is entitled to use this knowledge in his work. The author conceives that one function of an engineering expert in a valuation case

is to cooperate with his client's attorney with a view to securing fair consideration for his client. Very often the engineer must defer to his client's attorney in legal matters. Both are in turn bound by the opinion of the court or commission. Appeals are nearly always possible in the first instance and cases have arisen where the engineer's theory of the proper basis of valuation rather than that of the court or commission proved to be correct.<sup>4</sup>

#### THE REAL-ESTATE METHOD OF VALUATION OF WATER RIGHTS

The courts have held repeatedly that a competent and qualified real-estate expert is entitled to give his judgment as to the fair market value of a parcel of land, and in arriving at his judgment he is entitled to take into consideration his knowledge of prices paid in purchases and sales of real-estate similarly situated, making allowances for differences in physical and economic conditions affecting these properties as compared with the property to be valued.

Water rights are appurtenant to and are of the nature of real-estate and the same method of procedure is justified and is, in fact, generally adopted in the valuation of riparian rights, water rights or diversion rights.

The principal differences between the valuation of ordinary upland real-estate and the value of water rights arise (1) from the fact that the latter involves certain engineering factors which are not involved in the valuation of upland real-estate; (2) at a given time and in a given locality the available data as to purchases and sales of water rights are, as a rule, meagre as compared with the available data of purchases and sales of upland real-estate. As a result of this fact it is often necessary to use, in the valuation of riparian rights, data regarding purchases and sales which are more remote in time and position and differing more in character from the property being valued than in the case of ordinary land.

It is desirable that one who undertakes the valuation of riparian rights should have participated in purchases and sales of similar rights or properties in order to provide a background of experience and to ripen his judgment. It is not necessary that he should have participated in the purchases and sales which he uses as a guide in a particular instance. He may get his information from any source which he deems reliable. In case of court proceedings he will not,

<sup>4</sup> *Niagara, Lockport & Ontario Power Co. vs. Percy W. Horton et al.* New York Supreme Court, Appellate Div., Vol. 231, p. 402.

in general, be permitted to state in his examination in chief the actual prices paid in the cases used for comparison. These prices may, of course, be brought out on cross-examination, along with other data designed to ascertain the adequacy, reliability and applicability of the data used and the soundness of the resulting judgment.

#### DEFINITION OF MARKET AND MARKET VALUE

The theory of valuation generally applied by the courts in condemnation and diversion cases involving water rights is that the party whose property is taken, in whole or in part, is entitled to the diminution in fair market value of his property resulting from the taking.

Fair market value is defined as the price at which the minds of the two parties would meet if the owner was willing but not compelled to sell, and the purchaser was willing but not compelled to take the property and both were intelligent and fully informed as to the property itself.

From the definition of market value, it is not necessary that there should be a specific customer other than the taker for a particular property. A market is generally deemed to be sufficiently established if it is shown that properties of the same general character have been purchased and sold in the same locality. This rule, again, has a sound rational basis. It would hardly be necessary to show that a specific customer had offered to purchase a farmer's crop of potatoes in order to show that a market existed for potatoes in the same locality.

Attention is directed to the definition of market because of conditions that have arisen in recent years as a result of consolidation of local electrical companies and the general electrification of mills. In some localities where individual water powers were formerly in vogue, many of the mills have been electrified and the old water power plants either abandoned or taken over by electric companies. While water powers for individuals mills are still operative, particularly for papermills and some other industries, new power developments for this purpose are infrequent. It is usually possible for a public utility company to develop power within and transmit it through territory controlled by another company. Competition between companies supplying contiguous regions to secure desirable power sites has at times been keen and has often enabled owners of individ-

ual power sites, developed or undeveloped, to obtain good prices for their properties.

Unless such competition exists, the owner of a power site may find himself confronted with a situation where the existing utility company is the only available customer. Presumably the utility company can take the owner's property or not, as it chooses, and if taken, it can make its own price. Under these conditions it has been argued that where there is no competition, there is no market, and water rights have no value, and if they are required for some purpose other than power production, such, for example, as for public water supply, only a nominal compensation should be given the owner. This argument is not sound. If a power site exists in territory supplied by a given utility company, such that energy could be produced more economically than by other means, it may fairly be assumed that the utility company cannot afford to let that power site lie idle and will, in general, pay, sooner or later, a price reasonably representative of its economic value.

From another viewpoint, if the power site happens to be already owned by the utility company, no one would contend that it could be taken, in whole or in part, for diversion purposes, without the taker responding in damages. Other conditions equal, the fact of its ownership by an individual rather than by the utility company should hardly affect its economic value. Precisely this question arose in the case of the Niagara, Lockport & Ontario Power Co. vs. Percy W. Horton et al.<sup>5</sup> In that case a power site known as Light-house Hill, on Salmon River, New York, was being taken by condemnation for hydro-electric development. The court held that the value to be determined was the economic value for power production even though this was the very use for which the property was being condemned, and the condemnor was the only customer immediately available. Experience shows that even under such restricted conditions, where economically valuable power rights are purchased either for power production or for diversion purposes, substantial payment must be made therefor. This fact establishes market value of such rights in spite of the limited market available. The courts of New York and some other states generally hold, however, that where power rights are taken by the public for a special use, as, for example,

<sup>5</sup> New York Supreme Court, Appellate Div., Fourth Dept.; case argued October 9, 1930.

public water supplies, it is the diminution in their value for power and not their special value for water supply to which the owner is entitled. Federal courts are more liberal than some state courts in admission of proof of value, even permitting evidence in some cases as to value of water rights for water supply use, although the owner could hardly be presumed to use or sell them for this purpose under ordinary conditions.

#### THE FUNCTION OF CALCULATIONS IN WATER RIGHT VALUATION

The definition of market value above given and the examples cited point strongly to the conclusion that, in the last analysis, prices paid in actual purchases and sales of similar properties must and do govern market values in the case of water and diversion rights as well as in the case of real-estate and various commodities. Herein lies one of the greatest difficulties in the fair appraisal of riparian rights and diversion damages. Not only, as already pointed out, are actual examples of purchases and sales relatively meagre in most instances, but, as a rule, differences in physical characteristics of the properties and in economic conditions surrounding the properties are such that a direct derivation of value by the exercise of judgment cannot be attained as readily as in the case of the valuation of upland real-estate. The existence of this situation has sometimes led to the use of what may be called "calculated" valuations. A calculated valuation of a water power or of water rights is usually based on some assumed conditions; as a rule, in the case of water power rights, it is based on an estimate of the cost of replacing the power lost by some other available source of power. While courts frequently admit in evidence calculated valuations of power rights and riparian rights, they do not usually accept them as conclusive unless they are supported by judgment derived from actual purchases and sales of similar rights or properties. As already noted, the valuation of water rights, diversion rights or power rights usually involve elements that are not involved in the valuation of ordinary real-estate on, say, the acreage basis. These include, for example, the flow of the stream, the head or fall available and the amount, character and cost of development of the power. These are engineering quantities and their bearing on value makes necessary the use of engineering calculations of a type that do not generally enter into the valuation of upland real-estate. Such calculations have, therefore, a proper and important place in the valuation of water rights. The primary

object of such calculations in the valuation of water power or diversion rights should be to reduce the data to a basis for ready comparison such that the judgment can be most directly and simply applied and such that the number of elements of value to be determined by judgment alone is a minimum. It is no doubt possible in some cases for a competent real-estate appraiser, fully conversant with local values, to simply look at a parcel of land and arrive at a reasonably close estimate of its fair market value per acre, without any conscious mental processes or calculations. In case of a water power an attempt at a purely judgment valuation, without taking into account the many factors affecting the amount and character of the power and its economic use, would often lead to a result wide of the mark. On the other hand, a calculation alone, however detailed and exhaustive, is not likely to lead to the true value. The reason is that there are involved in the value of water power, as in the value of other real-estate, many elements which cannot be reduced directly to a basis of calculation. The effect of those elements which cannot be reduced to a basis of direct calculation is reflected in market prices. Here arises the necessity for tempering the results of calculations by judgment based on prices paid in actual purchases and sales. In arriving at the valuation there should be taken into consideration all the attendant and surrounding conditions and circumstances which affect the value of the property. If data are available regarding purchases and sales of other properties in the same locality, of similar character and at the same general time, the matter may be fairly simple. If, however, permanent changes in economic conditions or in the art or method of power development and use have taken place or are taking place, their effect must be taken into consideration in arriving at fair market value.<sup>6</sup> How important this factor of permanent changes in the arts or in economic conditions may be is well illustrated by the history of street railway or surface traction lines. Valuations of street railway properties

<sup>6</sup> In the author's experience, temporary as distinguished from permanent economic changes affect the marketability of riparian and water power rights far more than they affect the market prices. "Spot prices," "economic trends," "commodity levels," "flexible dollars" and other terms familiar in the argot of some professorial economists are fortunately of little applicability in this case. The variation in market prices of water power and diversion rights, except as affected by permanent economic changes, resembles, for example, the annual variation in mean temperature more than it resembles the diurnal variation.

made twenty years ago would be of little service in present-day valuation of such properties because of the change in local transportation resulting from the advent of the automobile. Similarly, in relation to water power, a question which has been much discussed in recent years is whether undeveloped water powers have any value at the present time because of advances and improvements recently made in the economic use of competing forms of power, particularly steam power. It has already been shown that some water power sites may be more valuable, others less valuable, today than under the earlier practice in power development. This fact must be taken into account if unit prices derived under the older conditions are to be applied at the present time.

#### DIVERSION AS AGAINST HYDRO-ELECTRIC PLANTS APPURTENANT TO INTERCONNECTED SYSTEMS

Few if any of the cases reported by the New England Water Works Association Committee related to diversions as against modern hydro-electric plants engaged in the generation of energy for public distribution. Apparently none of these cases represented diversions as against such plants interconnected with other plants operating as a unit for the supply of the power company's territory. Cases where diversions are made as against individual plants of an interconnected system have arisen and are certain to arise with increasing frequency in the future. The determination of the diminution in fair market value resulting from the diversion in such cases raises some interesting questions. In accordance with the fundamental rule already given, the damage resulting from a diversion is to be measured exclusively with reference to the plant or property against which the diversion takes place. If, however, the plant is operated in conjunction with other plants as part of a general electric production and distribution system, it may become difficult if not impracticable to base the estimate of diversion damages on the operation of the plant injured, considered only by itself. It may happen, for example, that the particular plant against which the diversion takes place is operated in conjunction with the other plants of the system purely for the production of what is called peak power, i.e., energy to meet the highest part of the distributing company's demand for an interval of a few hours during each day. The operation of the plant for this purpose may be highly profitable, although its operation as an isolated plant for the production of continuous power might be unprof-

itable. Evidently in the determination of diversion damages in such cases the plant against which the diversion occurs cannot be considered exclusively as an isolated or individual plant since its ability to operate for peak demand service depends upon the existence of the interconnected plants. The market value of the output is evidently to be considered for the output as used, not as it would be for an isolated plant subject to different market conditions and perhaps compelled to produce a less valuable grade of output.

#### FEASIBILITY OF POWER DEVELOPMENT

There is, theoretically, at least, some fall throughout the entire length of every stream. Every diversion of water against a substantial frontage along a stream therefore represents potentially a loss of power. Whether or not the diversion represents substantial damage through loss of power is another question. This depends primarily on the question whether the physical conditions are such that the fall, taken by itself or in conjunction with adjacent properties, is capable of feasible, profitable commercial development. One of the functions of engineering calculations in conjunction with valuations for diversion cases is to aid in determining this question. Obviously the power theoretically available is not capable of feasible development if, allowing nothing for value of the riparian rights, the interest, depreciation, and taxes on power house and equipment, plus station production expense, would exceed the value of the power output at prevailing wholesale prices at the power house wall. A higher interest or capitalization rate should be charged against an undeveloped than against a successful, developed project because money costs more for a new venture than for a seasoned investment. In cases where the owner cannot show any substantial damage resulting from the diversion, but there is a technical invasion of his property rights, he is entitled to nominal damages.

#### DIVERSION AS AGAINST UNDEVELOPED POWER SITES

The distinction between developed and undeveloped power sites has not always been kept clear and definite. Claims for diversion damages have sometimes been made in case of undeveloped power sites the same as if the power site was fully developed and in profitable use. It is a matter of experience that the market value of an undeveloped power site per horse power of available power is usually less than the market value of the water rights appurtenant to the

same power site when developed and in successful and profitable use. Assuming a case where there are two power sites equally good and of similar characteristics on the same stream, one of which is fully developed and in successful use, the other undeveloped, there are two principal reasons why the rights appurtenant to the developed site are more valuable than those appurtenant to the undeveloped site:

1. The business risks and hazards incidental to all new enterprises have been eliminated in the case of the developed site, and its market value is thereby enhanced because the purchaser of this site would know for a certainty that it could be economically developed and profitably used.

2. Let it be assumed that the developed site is already operating on a profitable basis. In the case of the undeveloped site a period of time must elapse before money invested in the riparian rights will begin to yield a reasonable return. This may be a short time, corresponding to the time required for development, if development is imminent, or it may be a number of years or an indefinitely long period if the conditions are such that the available power cannot be immediately marketed and hence such that the development of the site in the near future is not required. Suppose, now, the second site was to be purchased. The purchaser obviously could not afford, in general, to pay a price greater than the present worth of a sum which would represent the value of the undeveloped rights at the time when their development becomes justified; in other words, in case of an undeveloped site there must be deducted from its value as of the date of development the carrying charges, covering interest and taxes throughout the period between the date of purchase and the date of development. One procedure in such cases is to use a unit price derived from purchases and sales of similar undeveloped sites subject to immediate development and then scale down the resulting value by a present worth factor dependent on the time likely to elapse before development will take place. This may be somewhat indefinite, although in case of public utility companies serving definite territory the date at which the development of a given power site will be required may be capable of determination rather closely from the growth in energy demand. If the development is remote the present worth factor will decrease slowly with increase in time after the lapse of ten or fifteen years, so that an error in estimate of time is less important than when development is

imminent. For obvious reasons, valuations of undeveloped power sites are likely to be less precise than in case of power rights which are developed and in successful use.

#### INCOMPLETE OR PARTIAL OWNERSHIP OF POWER SITES

It is evident from the definition of fair market value above given that it is not necessarily the value to the owner nor is it necessarily the value to the taker which governs. It is the value of the property for the best use to which it could ordinarily be put, whether it is actually being put to that use or some other use by the owner. In arriving at the fair market value, as above noted, "all of the attendant and surrounding conditions and circumstances which affect the value of the property" are to be taken into consideration. Nevertheless, the final value must be that of the specific property under consideration and must not include that of some other property, although the value of the specific property may be enhanced because of the possibility or probability of its use in conjunction with other contiguous or adjacent properties. This, for example, is true in case of an owner of part of a water power site.<sup>7</sup> He is not to be deprived of its value simply because he might alone be unable to use the property to its best advantage, provided it is capable of being used and there is reasonable probability of its use as a part of a larger development, but the value allocated to it should be its own specific value. There is a sound practical basis for this procedure. It is a well-established fact that owners of parts of water power sites, developed or undeveloped, can and do sell their rights for substantial sums of money even though their ownership is incomplete. The value is not necessarily what it would be if the property was consolidated under one ownership but is, in fact, usually less.

If a power site comprises numerous parcels under different ownerships, then before the power can be developed, time and money must be expended in consolidating the rights. Some parcels may be purchased and remain subject to carrying charges, including interest and taxes, while other parcels are being acquired. There are increased legal and engineering expenses where numerous real-estate transactions are involved. These conditions go to make the market value of partially owned power rights generally less per unit of power available than those pertaining to complete power sites under one

<sup>7</sup> E. Maria Emmons vs. Utilities Power Co., Supreme Court, N. H.

ownership, ready for immediate development. Put in another way, experience shows that in general an undeveloped power site consolidated in a single ownership is worth more than the sum of the market values of its several components subdivided between a number of owners. This difference in value should be and generally is reflected in the cost of acquiring diversion rights as against individual parcels representing incomplete power rights as compared with that of acquiring similar rights as against undeveloped power sites consolidated under one ownership.

#### PARTIAL DIVERSION—CONSEQUENTIAL DAMAGES

What has thus far been said has related mainly to the valuation of a riparian or water power property as a whole. In many cases where diversion rights are to be acquired for public water supplies, the entire stream is not diverted. This constitutes a partial diversion. In cases of partial taking or diversion the owner is entitled not merely to the pro rata value of the part taken but to the full diminution in fair market value of the property resulting from the taking, i.e., he is entitled to the difference between the fair market value of the property as a whole before the diversion and the fair market value of the remainder after diversion.

It is worth while to give a little consideration to the nature of consequential damages in connection with partial diversions as against water power properties, developed and undeveloped. Primarily the nature of consequential damages is illustrated, for example, in case of upland real-estate, by the taking of all of the arable land of a farm, leaving the owner with the farm buildings only and the ground on which they stand. It cannot be presumed that the owner could acquire adjacent land which would enable him to continue the profitable use of his barns and buildings. Buildings may, of course, have some salvage value. This case corresponds more or less to the situation where there is a complete diversion of the flow of a stream as against a developed power site. The owner is left with the dam and power plant on his hands but without any water to operate it.

In case of a partial diversion of water power at a developed power site the owner of the power may be left with a dam and plant adequate for the full use of the stream, but with only a fraction of the water required for its operation. If he continues the use of the power he must carry the overhead expense incidental to the maintenance of the dam and appurtenant structures as they were before

the diversion; in other words, the overhead and operating expense after diversion, including interest, taxes and depreciation will remain substantially unchanged whereas the gross revenue from the operation of the plant will be reduced more or less in proportion to the fraction of the flow diverted. Under these conditions it may happen that the diversion of only a portion of the flow of the stream will render the continued operation of the water power unprofitable. That this may be true can easily be seen by a simple illustration. Suppose, for example, that a certain power plant before diversion could produce power worth, at wholesale, at the power house site, \$100,000 per year, at a total cost, including interest, taxes, depreciation and station expense, of \$80,000 per year. There would then be a net profit from the use of the power of \$20,000 per year. If, now, the flow of the stream is reduced 25 percent by diversion, the gross revenue may be reduced to \$75,000, whereas the production expense will not be materially decreased and the owner will be left with an income insufficient to pay station expense and fixed charges. In such cases municipalities or water companies may well give consideration to the advisability of acquisition of the property in full, thereby also making provision for any future diversion requirements and avoiding the necessity of paying direct and consequential damages substantially equal to the market value of the property as a whole, without acquiring the title thereto.

#### VALUATION ON THE POWER REPLACEMENT BASIS

While the real-estate method of valuation theoretically applies in cases of partial diversion, practically, and in particular cases, where the diversion is relatively small, the courts have in such cases frequently given consideration to the determination of value on the power replacement basis, particularly in recent years where purchased electric power is generally available to replace the power lost by diversion. It should be pointed out that here, as elsewhere, calculated valuations of replacement costs should not be solely relied upon but should be used as a guide to the judgment in determining the difference in fair market value of the property before and after diversion.

Where the power lost by diversion is a relatively small fraction of the total power, the payment to the owner of the capitalized sum necessary to replace in perpetuity the power lost by diversion seems to afford a simple and equitable remedy. The matter is not, how-

ever, always as simple as it appears. What the power owner really produces is a block of power at the power site, corresponding to wholesale power; what must be purchased to replace it is retail power, subject to distribution charges. It may easily happen that the cost of replacement of part of the power by purchased electric power at prevailing retail prices will produce a capitalized sum equal to or greater than the entire market value of the full power rights of the owner. In any event the owner would be fully compensated for all damages, direct and consequential, if paid the fair market value of his entire property, or some smaller sum depending on the conditions and on the fraction of his rights taken for diversion purposes. Even where the diversion is small and the cost of replacement is materially less than the market value of the property as a whole, the use of the replacement method often requires considerable care and the exercise of good judgment in its application. It is rarely the case that the owner of the power site has precisely the quantity, grade and character of power which his business requires. If, as is commonly true, his power is variable, sometimes less than his requirements, then as a rule he must purchase power in any event and the damage would not exceed the amount necessary to maintain his entire power supply, including both power produced and power purchased, in the same amount and of the same grade, as before the diversion. If power is purchased before diversion, then the owner must, in general, pay the usual monthly service or demand charge in any event. If, after the diversion, the amount of purchased power is increased, then the energy charge per kilowatt-hour may be decreased and the calculated damage on the power replacement basis would then be merely the difference between the cost of the total energy after diversion and the cost of the total energy required before diversion.

There is another point, however, which requires consideration in this connection. If the water power is not uniform and is at times less than the amount of power required by the owner, then the water power produced by the owner and the power lost by diversion are, in part, at least, secondary or dump power. He can use power when it is available and he must use it when available or allow it to go to waste. But in order to replace this power, firm or demand power must be purchased, available for use at irregular intervals and on the customer's demand. The cost of such energy purchased at retail is often much higher than the market value of the lower

grade power lost by diversion. On the other hand, payment to the owner of the value of the power lost as wholesale power at the power site and of the grade produced would often fall short of justice and would not enable him to continue his business unimpaired or undiminished in value.

It will be seen from the preceding that even where direct replacement of power lost by a partial diversion through purchase of electric power is to be considered, a wide variety of conditions may be involved, which require separate study and calculation in each case. None of these calculations may represent a fair measure of damage but, as in other cases, they serve as a guide to the judgment in arriving at the diminution in fair market value resulting from the diversion.

#### BASIS OF VALUATION OF DIVERSION RIGHTS IN USE FOR WATER SUPPLY PURPOSES

The market value of diversion rights when acquired against commercially feasible power sites is usually measured in terms of value of the rights for power production. If such rights are to be evaluated in rate cases or condemnation proceedings when and after they have been in use for water supply purposes, their market value should be determined as the cost of acquisition *de novo*. This is in accordance with the generally accepted theory of valuation on the basis of reproduction cost new. It is sometimes argued that in such cases the value should be predicated on either (a) the original cost; (b) the value of the power, if any, which could be produced from the rights as they stand, or (c) the sum which could be realized if these rights were or could be sold back to the owners of the original power sites. The use of the last two methods would in general lead to results much less than the cost of acquiring the rights and hence would be inconsistent with the reproduction cost theory of valuation.

It seems obvious that the value of such rights cannot be predicated on the market value of the power which could be produced from these rights as divorced from the power sites to which they were originally appurtenant. It may easily happen that because of the special nature of the diversion rights, commercially profitable development of power therefrom, when standing alone, is unfeasible. When such rights are acquired, severance damages are usually involved. If the rights were thereafter sold, not only would it be impossible to recover severance damages but the rights would stand in the posi-

tion of partial or incomplete power rights and would carry unit prices generally below those appertaining to the complete power sites from which they were originally segregated. Reproduction cost new in the case of such rights necessarily means the cost of acquisition at fair prices in the open market, not the amount for which the rights could be sold or salvaged if their use for water supply purposes was no longer required.

#### CONCLUSIONS

Among the principal effects of modern tendencies in power development in relation to the value and cost of acquisition of riparian rights for water supply and diversion purposes, the following may be mentioned:

1. The distinction in value as between developed and undeveloped power sites against which diversion is made is more sharply drawn than formerly.
2. Widespread electrical energy distribution has tended to restrict the market for individual power sites in some localities. Market value and marketability are related, and market restriction is consequently reflected in market value. Even where the market has become restricted to a single utility company as a possible customer, diversion rights as against commercially feasible and valuable power sites, individually owned, whether developed or undeveloped, can in general only be purchased or obtained by the payment of substantial damages, governed by the economic value of the rights for power production.
3. The development of widespread electric distribution systems has been accompanied by improved load diversity, interconnection of adjacent systems and the joint operation of power production units, both hydro and steam, in a given system. This has tended toward higher efficiency, greater utilization of available power and the production of a higher grade of hydro power than in the case of isolated hydro plants operating individually. Where these results have been accomplished they have resulted in increased economic value and hence in increased market value of the water rights appurtenant to such developments. This is certain to be reflected in the case of acquiring diversion rights where hydro-electric power is produced as compared with power rights not so completely or effectively utilized.
4. While there are many exceptions, particularly in the case of

large rivers, the present tendency is toward the use of hydro power in conjunction with storage regulation and diurnal pondage for the purpose of producing energy to meet variable or peak energy demand. Continuous or base power is more generally produced by steam. Energy available for peak load or demand service is both the most costly to produce by other means and the most valuable on the market, and water rights available for use in this manner are in general economically more valuable and command a higher market price than others not so favorably situated.

5. The valuation of diversion rights acquired and used or useful for present or future water supply purposes should be based on the cost of acquisition of the rights *de novo*, not on what may be realized from their sale back to the original owner.

## OUTSTANDING FACTORS IN UNDERGROUND WATER WASTE SURVEYS

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For convenience in the present consideration of underground water waste, leakage may be classed as "evident" and "non-evident." The evident leakage is the kind with which we are more or less obliged to be familiar—causing a flow observable at more or less distant points, resulting in public inconvenience or property damage and quite surely a complaint to the department.

Such leaks are frequently very small, but demand attention out of all proportion to the value of the water involved in order to minimize the features causing complaint. The non-evident leakage from which the flow is neither visible nor causing any complaint or immediate damage may, under favorable subsurface conditions, develop into a waste of tremendously serious proportions involving in the aggregate pumping and supply costs and even hastening the necessity of bond issues for additional sources of supply or equipment. Such leakage undetected may continue wasting indefinitely so that the saving accomplished by its location is tangible and can be shown in many cases to pay well for the necessary surveys. In contrast the complaint work on evident leakage where avoidance of serious damages is imperative usually involves much lesser waste in the smaller shorter lived leaks and the value of that work, while unquestioned, is far less tangible.

In New York since 1910 a special waste detection force under engineering supervision has been provided for the purpose of taking over from the repair shops or directly from subsurface utility corporations the most difficult location of leaks causing damage or complaint or otherwise in evidence. This force has operated principally in Manhattan and Bronx boroughs where rock-filled streets and trenches and other subsurface conditions favored development of underground leakage and rendered its location more difficult.

Previous to 1918 this force comprised but two field parties each

consisting of a caulker, three laborers, equipment and transportation and directed by a field engineer or engineering assistant. In 1918 two more field parties were added to better meet the needs. From 1918 to date these four field parties have been fully and profitably employed on such complaint work, together with gradient and capacity surveys for trunk main design and betterments, consumption and flow gaugings and other hydraulic work of the department.

The principal function of these four field parties in their water waste work has, of course, been the location of evident leaks causing complaint. However, it is estimated that the greater part of the water saving accomplished has been through the stopping of a greater number of non-evident leaks which had no bearing on the complaint in the search for the one, frequently small, that was directly responsible. Such non-evident leakage which, were it not for the work, would have continued an indefinite time is the basis for a conservative assumption used in computing the amount of water saved and the cost of the work per million saved, namely, that without that work the leaks stopped would have continued for an average of two years. Computed on that basis the cost of the complaint work has run roughly from \$2.50 to \$8.00 per m.g. saved. The limited size of this force to meet the demand upon it has precluded any systematic waste surveys.

The water shortage conditions of 1930 with dangerously low content of reservoirs and increasing consumption approaching the safe yield of watersheds compelled serious consideration of waste reduction measures. These measures included the organization of an additional force, previously advocated under lesser emergency conditions, to make surveys for the location and stopping of the underground leakage presenting no visible evidence which experience in the complaint work had suggested was responsible for a much greater waste than had been stopped in the correction of evident leaks.

The requested force with the necessary equipment and engineering overhead to provide four additional field parties was allowed the latter part of that year and was fully working on underground waste surveys Jan. 1, 1931.

#### EMERGENCY SURVEYS

The emergency conditions called for the most direct methods to stop the greatest possible leakage in the shortest possible time. The usual preliminary studies by consumption gaugings, subdivisions,

etc. to localize the wasteful sections were therefore discarded and the aquaphone survey, believed to be a novel method for the purpose of thoroughly covering a large distribution system, was adopted.

The results accomplished in the past three years have surpassed all previous estimates and have revealed some factors of underground non-evident leakage that are of more than local interest and that may be of useful application in cities other than New York.

#### *Results with the aquaphone*

The aquaphone is the simplest of many devices designed to detect leakage in water pipes. In fact, horny handed caulkers and some



FIG. 1. LISTENING FOR LEAK

laborers are not above being "discovered" using the aquaphone instead of their "professional" methods, such as using their ear in contact with the iron bar or taking the bar end in their teeth while closing their ears with their fingers. They do seem to have a decided aversion to the use of the "stethoscope harness" that goes with the more elaborate and sensitive devices, especially before the curious audience that invariably gathers in a busy street when such conspicuous devices are being used.

The aquaphone consists of a metal disc attached to the end of a small rod and enclosed in a telephone receiver shell with the rod

protruding through a plug in the opening normally provided for the wire. Leaks are detected by a slight vibration or sound picked up with the aquaphone placed on metal connections or fixtures on the mains, such as hydrants, street valves and services or on bars driven to contact with the main.

The intensity and character of this sound vary tremendously due to widely varying conditions, including among others, the size or the mass of metal in the main, the character of the break or opening, density of soil, whether leak is submerged or discharging into open rock-fill, etc. Efficient results can therefore be accomplished only by an ear trained and experienced in detecting the faint variable



FIG. 2. REMOVING BAR USED FOR SOUNDING

leak sound and in identifying it from the generally more intense vibration due to surface and underground traffic, steam boilers, regulating valves, motor hum, machinery grind and other like sounds. Thorough aquaphone detection work requires a man of assistant engineer or engineering assistant grade with a sensitive experienced ear and one who is "water waste conscious." These essential qualifications among skilled or unskilled laborers are rare and efficiency of properly qualified men is greatly improved by long experience.

A number of more sensitive and amplifying devices have been tried out, but under New York conditions have almost unanimously been

discarded by experienced men as giving all sound vibrations an unnatural intensity that adds to the confusion and difficulty of recognizing the leak sound. Instruments for "selective tuning" to eliminate other than leak vibration have not as yet passed the laboratory stage, probably due to the fact that we are dealing with "noises" rather than with "tones" with a definite frequency and all being "broadcast" without carrier waves.

The aquaphone surveys in New York have thus far been principally confined to Manhattan and Bronx, where past experience had indicated a fruitful field. The results have proven the correctness of the previous assumption based upon complaint work that a tremendous non-evident underground leakage existed and the amount stopped has been fully  $2\frac{1}{2}$  times "optimistic estimates" previously made.

The amount of underground leakage corrected each year has fully equalled the normal annual increase in the five-borough consumption in pre-depression times. The work, therefore, has postponed for three years the necessity of bond issues for development of major additional sources, such as the \$220,000,000 Delaware River project and at a cost that is but a fraction of 1 percent of the interest and sinking fund charges on that amount.

The cost per million gallons of conservatively estimated saving has averaged \$2.30 as against \$45.00 per million gallons as a low valuation of the water delivered to the city line and exclusive of distribution costs.

The field forces on all waste detection are fully equipped to handle the three stages in the stopping of underground leaks—detection, location and repair—independently of the repair shop force except for major repairs, such as broken mains, re-running of large joints, etc. In such cases, the excavation is made by the waste survey force and the repair turned over to the shop. In New York services belong to the property owner. Therefore, notice to an owner to repair a leaking service is given only after the tap has been excavated for a test to prove that the vibration detected is not from a leak on the city main. The opening is then turned over to the owner's licensed plumber on the usual permit. On both complaint and survey forces it has been found inefficient and impractical to coördinate repair shop and waste survey work without serious delays and interference with both.

Since November, 1930, the boroughs of Manhattan and Bronx

have been covered twice with aquaphone surveys. A third and more intensive survey was started the first of the present year. The first

Weekly Report of Water Waste Force

Leaks stopped week ending February 24, 1934

<u>Location</u>	<u>Description</u>	<u>1000 G.P.d.</u>
<u>Survey Work</u>		
Intersection West 182nd St. and Davidson Ave., Bronx.	Transverse break of 6" main. Opening 16"x4" (average) P.55; C.60	1947
282 Monroe St. east of Jackson Ave.	3/4" tap, 1" live lead service broken at house line 31' from main. Pressure loss 48#	82
381 East 144th St. west of Willis Ave., Bronx	Leak in cellar (inside leak) on 1/2" galv. iron live service pipe at joint. Opening 1/4" x 1/16". P.30; C.60	2
Canal St. west of Varick St. Holland Tunnel Building.	Transverse split on 6" private main to tunnel building. Separation 1/8". P.53; C.60	563
88 Franklin St. east of Church St.	3/4" tap, 1" live lead service. Leak on tap coupling. Opening 1" x 3/32". P.50; C.60	21
2256 Walton Ave. bet. 182nd and 183rd Sts. Bronx.	1 1/2" tap, 2" live lead service leaking about 5' from main. P. loss 9#	208
128 Hudson St. south of Beach St.	1" live lead service (inside leak) Leak in cellar on street side of valve. Open. 3/4"x3/32". P.51; C.60	16
In front of 544 E. 142nd St. west of St. Ann's Ave. Ex.	Transverse break of 6" main. Open at top 1/4"; on bottom 1/16". Average opening 5/32". P.47; C.60	662
2355 Morris Ave. south of 184th St. Bronx.	1" tap; 1 1/2" live service leaking about 6' from main. Pres. loss 4#	60 3561

Complaint Work

Ft. Washington Ave. and 173rd St.	12" main line valve (packing) Est.	3
West 170th St. east of Ft. Washington Ave.	Repacked 6" hydrant gate. Est.	2
Total		5 3566

*Frederic B. Nelson*  
Assistant Engineer.

FIG. 3. TYPICAL WEEKLY REPORT

and second surveys were conducted to meet the threatened water shortage emergency as effectively and promptly as possible.

The first survey included, in the detection work, an aquaphone

sounding on each street valve and hydrant only with the objective of locating as rapidly as possible the largest leaks.

Detection work on the second survey included in addition to valves and hydrants the aquaphoning of probably 50 percent of the services inside the buildings, aiming to detect service and main leaks too small or too distant to be detected at the valves and hydrants.

TABLE 1

*Comparison of successive aquaphone surveys—Manhattan and Bronx Boroughs*

	SURVEY			
	First	Second	Ratio No. 2 to No. 1	Third (started)
	11/1/30-3/1/32	3/1/32-1/1/34		1/1/34-5/1/34
Months required.....	16	22	1.37	
Number of leaks located....	209	471	2.25	146
Number of leaks per month..	13.0	21.4	1.65	36.5
M.g.d. located.....	33.791	54.875	1.62	14.642
M.g.d. located per month...	2.12	2.49	1.17	3.66
Average size of leaks (m.g.d.).....	0.161	0.116	0.72	0.100
Total cost.....	\$54,854	\$94,597	1.72	\$25,114
Cost per m.g. saved (2 year basis).....	\$2.22	\$2.36	1.05	\$2.35

#### Classification

	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Total.....	209	100	471	100	146	100
Live services.....	87	41.6	253	53.7	84	57.5
Abandoned services.....	19	9.1	37	7.9	8	5.5
Valve leaks.....	9	4.3	24	5.1	7	4.8
Joints in mains.....	83	39.7	131	27.8	17	11.6
Broken mains.....	6	2.9	11	2.3	7	4.8
Inside plumbing.....			13	2.8	23	15.8
Miscellaneous.....	5	2.4	2	0.4		

More detailed aquaphoning, bar soundings, etc. for final location of leaks was, of course, the same in both surveys.

A third survey, more intensive and including aquaphoning of all services and available contacts with the mains was started January 1, 1934.

The comparison in table 1 of the first and second surveys is of interest as illustrating the relative effectiveness of the two methods,

the increasing efficiency of the force and other features. Results of the third survey to date are given for a like purpose, but in a limited degree as that survey as yet has covered but a fraction of the area, including the more difficult portions.

In any study of table 1, it is important to bear in mind that the results given under the second survey were accomplished after the ground had been covered and the leakage of the first survey eliminated from the field only a few months previously. With this in mind the table is strikingly significant as showing:

1. By an increase of but 5 percent in the cost per m.g. saved to only \$2.36 that we are as yet a long way under the economic limit of cost of the work as compared with any conservative estimate of the value of the water saved.

2. That we are gaining on the accumulation of non-evident leakage as indicated by the smaller average size of the leaks found on the second coverage of the area.

3. An increasing efficiency of the force is evidenced by the stopping on the second survey, as compared with the first, 65 percent more leaks per month of 72 percent average size at only 5 percent increase in the cost per m.g. saved.

4. On the second survey  $2\frac{1}{4}$  times as many leaks were found, indicating a decided increase of effectiveness of the method used.

The classification of leaks is quite similar in the two surveys, but it is interesting to note that within a fraction of one percent on both surveys, live services and joint leaks combined constitute 81 percent of the total number of leaks. However, in the first survey the number of joint leaks was closely the same as the number of service leaks, while in the second, where an increase in the ratio of service leaks would be anticipated from the difference in survey methods, live service leaks numbered twice the joint leaks.

The third survey thus far shows by comparison the effect of the still more intensive methods bearing in mind that very largely leakage stopped on the first and second surveys has been eliminated from the field.

The number of leaks per month has again been increased while the average size has decreased—a credit to increasing efficiency of the force in the fourth year of their work. The total m.g.d. stopped per month has been increased at a cost per m.g. saved that is practically the same as that of the second survey.

In the classification of leaks in the third survey the percentage of

SUPPLY - GALLONS DAILY	SEPTEMBER 1931	OCTOBER 1932	MAY 1933
AVERAGE DAILY SUPPLY	13,261,000	11,987,500	12,617,000
MAXIMUM	17,398,000	16,800,000	16,150,000
MINIMUM	7,710,000	6,800,000	7,350,000
PERCENT NIGHT RATE OF AVERAGE	58.1	56.7	58.25

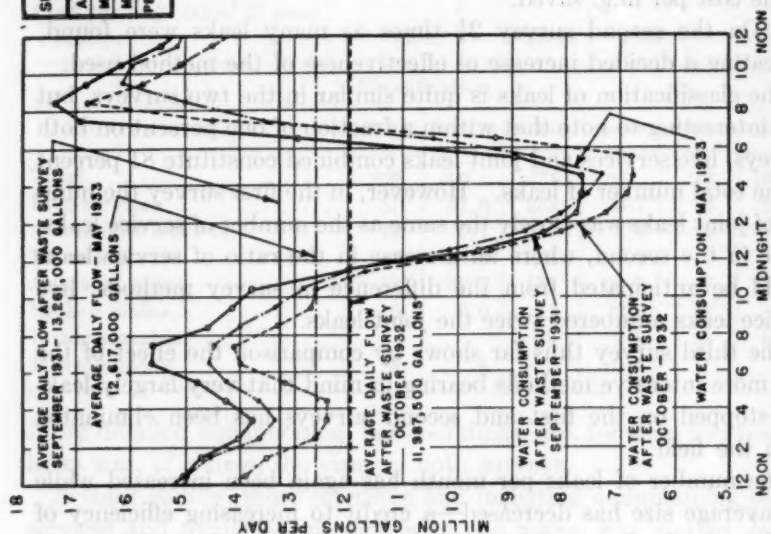
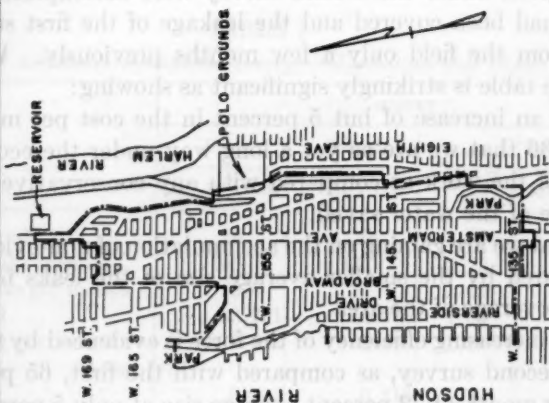


FIG. 4. BOROUGH OF MANHATTAN, TOTAL WATER CONSUMPTION—FULL CATSKILL SERVICE NORTH OF MANHATTAN VALLEY

live services and joints combined has decreased from 81 to 69, but the percentage of service leaks is five times that of joint leaks instead of twice as in the second survey. If, however, the materially increased percentage of inside leaks in the third survey be included as services, the combined services and joints will be 85 percent and the number of services over six times the joints. Such results are logically to be expected in the more intensive method.

### *Results in lower Manhattan*

The results of surveys in the lower end of Manhattan, south of approximately Canal Street, have been of interest as a more acid test of the aquaphone method and its limitations.

This area includes some of the greatest congestion of subsurface mains and structures to be found in the city. Distribution mains are mostly 12-inch and larger, the 6-inch mains having been quite generally replaced. The soil is somewhat sandy but compact with bed rock at depths requiring caisson methods of foundation construction. From the character and consistency of the soil one might be justified in assuming that here all leakage of consequence would fall in the evident class by showing at the surface or pushing its way into basements or subsurface structures and corrected through complaint channels. This area is one for which we might be justified in making the familiar assertion "We have no underground leaks. They all come to the surface." The first survey including aquaphone sounding on all valves and hydrants seemed to prove that assertion.

This area was covered in November and December of 1933 by the finish of the second survey and by the beginning of the third survey in January and February of 1934. Comparison of results of this four-month intensive survey with those of the first survey in the same area show by a marked contrast.

1. That non-evident leakage does exist in substantial amount in the compact soil of lower Manhattan.
2. That it can be located only by an intensive survey by experienced men able to detect and recognize the faint indications.
3. That the cost per million gallons saved, while higher than in less congested and less difficult areas, is well below the most conservative possible estimate of the value of the water saved.

The first survey, aquaphoning all valves and hydrants, detected and located but three leaks in this entire area. The second and

third surveys, including the aquaphoning of all services in addition to valves and hydrants, resulted in the location and repair of 47 leaks amounting to a total of 5,464 m.g.d. at a cost of \$3.11 per m.g. of saving estimated on the two-year average life basis. These 47 leaks include three broken service mains 4-, 6- and 8-inch, totaling a discharge of 2.4 m.g.d. or an average of 800,000 g.p.d. which were not showing on the surface, had not resulted in sagging of pavement under heavy traffic or developed any other visible evidence.

Table 2 is of interest as showing the relative number of the different classes of leaks and their average size, all in the non-evident class, running under compact soil and subsurface conditions without coming to the surface or causing any visible evidence or complaint.

The results further suggest the limitations of the aquaphone survey method and that more non-evident leakage exists undetected by

TABLE 2

*Leaks stopped by aquaphone survey in Manhattan south of Canal, Division and Grand Streets November, 1933 to February, 1934, inclusive*

CLASSIFICATION	NUMBER		1000 G.P.D.		AVERAGE
	Total	Percent	Total	Percent	
Totals.....	47	100	5464	100	116
Live services.....	33	70	1217	22.4	38
Abandoned services.....	4	8.5	250	4.6	62
Joints.....	7	15	1590	29	199
Broken mains.....	3	6.5	2407	44	802

the methods thus far used. Such methods have covered but imperfectly the services and 12-inch and smaller distribution mains with soundings only on the widely spaced hydrants and valves of the larger mains where serious leaks can be detected at distances of only a few feet.

Occasionally the necessarily more intensive searches made by the complaint force verify this conclusion.

A complaint from Wall and Pearl streets within this area necessitated such a search. Practically within a radius of one block from this intersection four leaks were located totaling 240,000 g.p.d. at a cost of \$5.27 per m.g. saved, including two joints, one live service and one abandoned service. One 12-inch joint was discharging 120,000 g.p.d.—non-evident and undetected by the aquaphone survey, probably because of the limitations mentioned. Two leaks were found by the survey about two blocks from this location.

A similar search was made by the complaint force in a rectangular area from 8th to 14th streets, including on each street the three long blocks between Avenue B and Second Avenue. This area is outside that south of Canal Street and has less subsurface congestion but quite similar soil. In this area 19 non-evident leaks were located, totaling 491,000 g.p.d. and averaging 26,000 g.p.d. at a cost of \$5.10 per m.g. saved. This is exclusive of three large leaks on house sewers and several hydrant and gate valve leaks too small to be included.

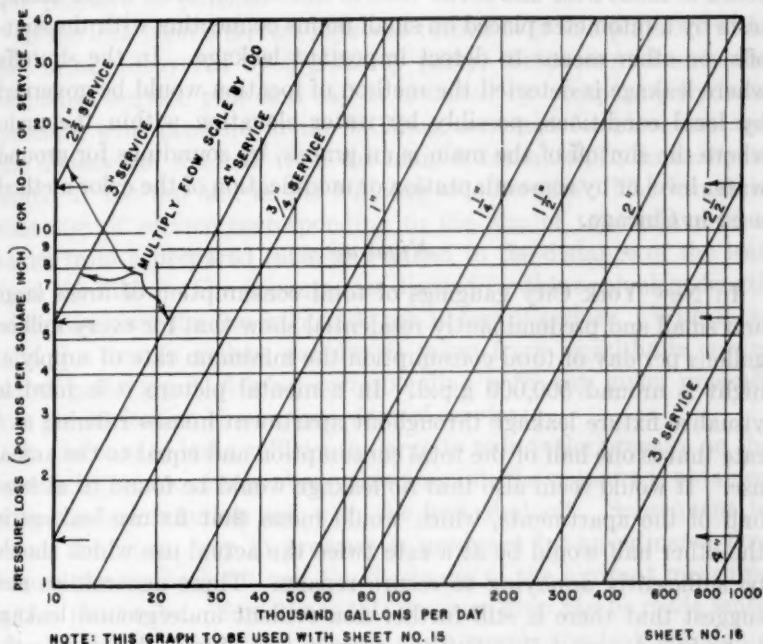


FIG. 5. FLOW CORRESPONDING TO A GIVEN PRESSURE LOSS IN 10-FEET OF SERVICE PIPE

Basis: Williams and Hazen's Tables,  $C = 120$

The above rather detailed account of the survey work south of Canal Street is given in support of the contention that fairly prompt and efficient correction of leakage causing complaint coming to the surface or otherwise in evidence is *not* proof that the system has no non-evident subsurface leaks. Even with compact soil conditions the survey has shown that a broken 6-inch service main discharging 800,000 g.p.d. may still fall in the non-evident class.

The work further shows that such non-evident leakage was not revealed by a preliminary survey and can be located only by intensive methods.

The cases on the complaint work are cited to show the existence of non-evident leakage that even escapes aquaphone survey methods and can only be gotten by locally concentrated effort, but at a cost still within an economical limit.

As before mentioned, the aquaphone survey detects little, if any, of the leakage on the mains above the distribution size. It is proposed to make hose-and-meter tests of shutoffs on these larger mains, tests by a pitometer placed on small mains connecting with the shutoffs, or other means to detect important leakage. In the shutoffs where leakage is detected the method of location would be governed by local conditions, possibly by water elevation within the main where the shutoff of the main is on grades, by soundings for ground water level or by some adaptation or modification of the color method used in Chicago.

#### *Night use*

In New York City gaugings of total consumption of areas large and small and predominantly residential show that for every million gallons per day of total consumption the minimum rate of supply at night is around 500,000 g.p.d. In a mental picture it is hard to visualize fixture leakage throughout apartment houses running at a rate that is one half of the total consumption and equal to the actual use. It would seem also that no leakage would be found in at least half of the apartments, which would mean that fixture leakage in the other half would be at a rate twice the actual use which should be sufficiently annoying to secure repairs. These generalities also suggest that there is still further non-evident underground leakage to be found, especially when the average size of leaks located on the second aquaphone survey was over 100,000 g.p.d. or an ample supply for one block of fair size apartment houses.

#### *Calculation of amount of leakage*

The determination of the amount of leakage stopped on the survey and complaint work is based upon a computation of the discharge of the individual leaks. Very few, when necessary, are conservatively estimated. Even small ones that are uncovered are sometimes measured by timing the discharge with a pail or container of known capacity.

Where the discharge is from a crack or opening, the minimum dimensions of the opening are taken and the pressure obtained from the nearest hydrant or fixture. The orifice formula is then used with a coefficient of 0.60 found from tests to be conservative for ragged and narrow openings. For round smooth openings 0.80 coefficient has been found to be fairly accurate. This formula is combined with the necessary constants and reduced for convenient use to the form in which gallons per day is equal to a constant times the area of the opening in square inches multiplied by the square root of the pressure in pounds.

If the leak is on a service pipe and turned over to a plumber without being uncovered by the survey party, the pressure loss in the combined service pipe and tap is obtained by comparing hydrant pressure with pressure in the building corrected for elevation and the distance of the leak from the main is estimated by intensity of sound at the tap and in the building or otherwise. The length of that size of service corresponding to the size of tap uncovered is taken from a prepared table and added to the distance of the leak from the main. The pressure loss divided by this equivalent length of service gives the loss in pounds per 10 feet of service. With these data the flow in gallons per day is taken from logarithmic curves showing the g.p.d. flowing corresponding with any given pressure loss per 10 feet on the various sizes of services.

In the case of leaks sufficiently large to reduce the pressure on the system by an accurately observable amount, the pressure is obtained with the leak running and with the leak shut off. Subsequent to repair the same drop in pressure is produced by an adjusted flow from a nearby hydrant and the discharge of the hydrant measured with a pitot tube. Sometimes this pressure drop can be made sensitive by so arranging street valves as to supply the leak through a restricted feed or long length of small pipe. Occasionally a direct measurement is made with a pitometer.

These several methods applied with variations are based upon tests and computations and at frequent opportunities are verified by actual measurements. The formulae or coefficients used are adjusted on the conservative side. Tap and service leaks when they are uncovered and the defective part can be obtained from the plumber, are tested out at the testing station by weighing of the water and stop-watch timing of the discharge. Such tests have shown the computations to average fairly accurately and below 100 percent.

## DEPARTMENT OF WATER SUPPLY, GAS &amp; ELEC.

## HYDRAULIC DATA

PIPE LENGTH EQUIVALENTS OF TAPS  
AS TO PRESSURE LOSS

SIZE OF TAP	EQUIVALENT LENGTH OF PIPE IN FEET								
	5/8"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
5/8"	5.4	13	44	166	359	1025			
3/4"		6.1	22	83	177	500	1500		
1"			6.1	26	55	157	486	1400	
1 1/4"				10.4	25	70	212	512	2080
1 1/2"					11.4	36	108	257	1055
2"						10.8	36	86	350
3"								16.8	76
4"									22.8

NOTE: PIPE LENGTH EQUIVALENTS ARE FOR SMOOTH INTERIOR SIZES OF C=120 WILLIAMS, AND HAZEN'S TABLES - WROUGHT IRON TO AND INCLUDING 3", AND SMOOTH CAST IRON FOR 4". THIS TABLE IS TO BE USED WITH SHEET NO. 16

SHEET NO. 15

FIG. 6

Gauging of consumption of areas before and after waste surveys is not a dependable method of determining the saving accomplished as the consumption due to changing weather or other conditions is very apt to change daily or weekly by an amount equivalent to or greater than the total of the leaks repaired.

This has recently been tried out on four experimental districts of different residential character. In the four districts a few underground leaks of sufficient size to be easily detected on the aquaphone survey were located and repaired and a house to house inspection secured repair of real fixture leakage. The total of consumption of the four districts after repair of leaks was 0.1 percent greater than before, even after the second gauging in each case was adjusted by the percentage of change in consumption of the city for the corresponding dates. There was, however, a reduction of 4 percent in the night rate which, applied to the first gaugings, indicated a saving of 151,000 g.p.d. which was practically all in the two districts of low residential character.

#### CONCLUSIONS

1. The aquaphone method under New York City conditions has proven to be most effective in locating directly non-evident underground leakage sufficient in amount to offset annual increase of the city's normal consumption and thereby has postponed interest and sinking fund charges on large expenditures for additional supply by at least three years. This has been accomplished at a cost that is but a small fraction of the value of the water saved and a fraction of 1 percent of such interest and sinking fund charges.
2. The aquaphone method is limited to the smaller distribution mains and services and undoubtedly does not detect all leakage on them.
3. That the amount of non-evident leakage is not fully realized is suggested by gaugings of residential districts in which there persists a minimum night rate that is 50 percent of the daily supply.
4. A water waste force should have qualified engineering overhead. Each field party should have competent supervision and be fully equipped for detection, location and repair independently of repair shop force.
5. The amount of water saved is best determined by computation of the individual leaks stopped based upon obtainable field data.

6. The results in certain sections of New York City suggest that even under more adverse subsurface conditions of other cities the method may be used to stop non-evident leakage at a cost well below the value of the water saved.

7. The oft cited fact that all leaks appearing at the surface or other visible points are promptly repaired is not proof that the soil condition is such that all leaks perform that way or that non-evident leaks do not exist.

### DISCUSSION

J. B. EDDY (*Engineer, Water Pipe Extension, Chicago, Ill.*): The first and most important factor for underground water waste survey work is a trained personnel under direct engineering supervision.

The field crew used in this work in Chicago is quite similar to that used in New York and consists of a Junior Engineer, a caulker (or plumber), two laborers, with a chauffeur, and a one-ton truck. The field crew is responsible for the test by which leakage is indicated and for the locating of each leak. The Junior Engineer, or his immediate superior, an Assistant Engineer, is present when a leak is dug up.

The work of digging up and repairing the leak is done by regular maintenance forces under the District Superintendent on an order originated by the District Engineer.

The forces of the District Superintendent and District Engineer are under one division control, consequently no confusion or delay results in the handling of the work.

After all of the leaks in any valve section have been repaired a second test is made to prove the section tight.

There are advantages in this system in that the field engineering crew, as soon as it has located a measured leak, moves on to test for and locate other leaks, the work for which it is trained and equipped, while the maintenance force digs up and repairs the leaks, the work for which it is best fitted. The caulkers and laborers used by the field engineer are drawn almost entirely from experienced maintenance forces. The District Superintendent is directly responsible for the opening of the street and for properly caring for the opening after backfilling until it is repaved. Since the repaving is done possibly some months after the repair is made, and the engineering field crew has moved to a new field, it is highly important that the District Superintendent be made responsible for the street opening.

There are now twelve field engineering crews locating underground

street leakage in Chicago. The length of experience of the men in this work varies from 25 years for the older men to a few months for the men recently assigned to the work. An engineer coming into this work is "broken in" by an experienced engineer, and each man in charge of a field crew is under direct supervision of an experienced engineer.

The second important factor is the choice of method to be used in conducting the survey for underground unseen leaks. The District Engineer is responsible for a choice of method, which he must have approved by the Engineer of Water Pipe Extension. The District Engineers are men of long service in their respective districts and know the local conditions.

The surveys are made by a number of methods. When weather permits the shutting off of roundways (curb cocks), closed tests are made. This method eliminates the confusion that arises from numerous plumbing fixture leaks, underground leaks within premises, or the prevalent wilful waste of water through plumbing fixtures, usual when service is not metered and when water is used freely for cooling purposes. All of these leaks or waste "telegraph" their noise to the man in the street trying to locate leakage with an aquaphone. In shutting off each stop-cock, an aquaphone is placed upon the shut-off rod before and after closing to determine whether or not water was passing the shut-off cock at the time of operating or whether a sound still is heard after shutting off stop-cock.

After closing off the services two principal methods of locating leaks are used, the one by aquaphone and sounding rod, the other by the dye method.

The aquaphone method is, and has been for many years, invariably used where mains and services have normal cover, that is  $5\frac{1}{2}$  to 6 feet, and sewers are of normal depth, which is from 7 to 9 feet. In fact, the aquaphone has been the "mainstay" in locating unseen (but not unheard) leaks, in 1,695 miles of mains tightened up during the past 18 years.

The "dye method" has been used upon about 50 miles of mains where unseen and unheard leaks existed. The conditions where the dye is used have been described in previous papers before this association. Possibly too much time and space were given in those papers to the description of the "dye method," but the fact remains that its use in Chicago has made possible the saving of 12,500,000 gallons per day of unseen and unheard leakage. It has also made

possible a far greater saving by allowing the continuance in service of mains which otherwise would have been replaced because of the loss of water from them which could not have been found and stopped, without dye, except by completely stripping the mains and services. In some cases mains have been replaced because of their inaccessibility which made repairs too costly, but in most of the cases where dye was used the mains and services were tightened up and put back to work.

Aquaphone surveys, without shut-off of services at the stop-cock, have been used quite freely for about 20 years. Leaks reported by utilities and others, as observed in vaults, manholes, conduits, sewers, and other places underground, are located usually by aquaphone or leak detector. This work can usually be done in daylight, but in heavy traffic streets it is necessary often to work in the early morning hours when traffic and attendant noises are at a minimum.

Aquaphone surveys are also made when cold weather conditions do not permit a shut-off of service. These surveys have also been carried on during other seasons where local conditions seemed to warrant. During the past two years, 157 miles of mains have been covered by the aquaphone survey where it was not considered necessary to shut off service. These surveys were in outlying residential sections, with mains of normal depth and of comparatively recent construction. In a number of these sections, when the aquaphone survey indicated underground leaks, a closed test was made to verify the result. These check tests showed in every case that the open aquaphone survey had located all of the leakage which could economically be stopped.

Experience in underground leakage work in Chicago bears out Mr. Nelson's statement that underground unseen (and sometimes unheard) leakage exists in every soil where water mains and services are laid, and it is indeed unwise to boast that a distribution system has no underground unseen leakage.

A great many of the leaks located by Mr. Nelson by his aquaphone survey—because of soil conditions—would have gone on indefinitely, and therefore his estimate of two years for each leak is far too modest; however, he can safely assume his position without fear of losing an argument should one arise.

Experience in Chicago bears out, for the most part, Mr. Nelson's conclusions concerning underground leakage surveys.

Question No. 1 which will be asked of the engineer who proposes to spend public money to stop underground street leakage is:

#### WILL IT PAY TO STOP THE LEAKAGE?

In replacement of mains to eliminate leakage a pictorial record of conditions is available and has been found a most convincing argument to those charged with the appropriation of money. Where mains are not to be replaced, additional facts must be produced, such as the amount of leakage to be eliminated, and the cost.

In the older part of the city it is comparatively easy to prove your point—in outlying sections where mains are of normal depth and of fairly recent construction, it is not so simple, and it is in these sections that the aquaphone survey alone may be used and the cost of work kept down to an economical point.

## THAWING FROZEN SERVICE PIPES

BY REEVES J. NEWSOM

*(President, Community Water Service Company, New York, N. Y.)*

Within the experience of most water works operators now active in this work, the problems resulting from frozen services and mains were most acute in the winters of 1917-18 and 1933-34. The observations and conclusions presented in this paper are based on a study of data and conditions in that northeasterly section of the United States bounded by the State of Pennsylvania northerly to the Canadian line and easterly to the Atlantic Ocean.

In comparing those two periods and in seeking to analyze the causes resulting in severe freeze-ups, it develops that certain factors definitely contribute, although sometimes contrarywise, to produce the extremely trying and costly experiences such as so many water works plants have passed through this last winter.

These primary factors may be listed, although not necessarily in the order of their importance, as follows:

(a) The variation of the temperature from normal during December, January and February and the distribution of that variation.

(b) The amount and the distribution of snowfall during these months.

(c) The amount of rainfall during the preceding months of September, October and November.

(d) The degree of snow removal.

(e) The amount and character of construction works in progress on roads during the winter.

The study of temperature, snowfall and precipitation records as recorded at Boston, Albany, New York, Buffalo and Pittsburgh (shown in table 1) and some observations at certain intermediate points, reveal as regards factors *a*, *b* and *c* these pertinent facts. At Boston the temperature in the winter of 1917-18 was on the average 9.1 degrees below normal against an average of 8.4 degrees in the past winter, although the difference was more evenly divided over the three months in the former period. The differences in snowfall and early fall precipitation, however, are more decisive. In the '17

period the snow was 12 percent below normal, while in '33-'34 it was 53 percent above normal. The fall rainfall was 2.37 inches below normal in the first case and 4.50 inches above normal last year.

Thus, as would be indicated, the freeze-ups were much more severe sixteen years ago in this territory than in the past winter, excepting only in cities well north of Boston. Here factor *d*, the

TABLE 1

*Comparison of temperature, snowfall and precipitation (Fall and Winter of 1917-18 and 1933-34)*

Mean temperature, degrees F.

	BOSTON			ALBANY			NEW YORK			BUFFALO			PITTSBURGH		
	'17-'18	'33-'34	Normal	'17-'18	'33-'34	Normal	'17-'18	'33-'34	Normal	'17-'18	'33-'34	Normal	'17-'18	'33-'34	Normal
December.....	23.7	26.8	32.3	17.2	24.7	28.5	25.0	32.9	35.0	20.8	27.1	29.8	24.5	35.3	34.2
January.....	21.0	29.6	37.8	14.0	25.2	23.1	21.6	34.4	30.9	14.1	27.5	24.6	18.6	33.8	30.7
February.....	26.9	17.5	28.8	22.0	12.1	24.1	29.6	19.8	31.3	23.1	11.6	24.3	32.7	19.7	32.3
Average below normal.....	9.1	8.4		7.5	4.2		7.0	3.4		6.0	4.1		7.1	2.8	

Snowfall (inches)

	BOSTON	ALBANY	NEW YORK	BUFFALO	PITTSBURGH
December '17-February '18 (Inc.).....	28.5	28.8	28.8	31.0	33.8
December '33-February '34 (Inc.).....	49.3	46.4	43.5	46.7	20.3
Normal.....	32.3	35.4	24.2	53.4	22.5
1917-18 variation from normal, percent.....	-11.8	-18.6	+19.0	+52.0	+50.3
1933-34 variation from normal, percent.....	+52.7	+31.0	+79.7	-12.3	-9.8

Precipitation (inches)

	BOSTON	ALBANY	NEW YORK	BUFFALO	PITTSBURGH
September-November, 1917 (Inc.).....	7.83	7.92	9.10	10.36	7.45
September-November, 1933 (Inc.).....	14.70	10.44	11.00	5.28	6.34
Normal.....	10.20	8.62	9.88	9.23	7.89
1917 variation from normal.....	-2.37	-0.70	-0.78	+1.13	-0.44
1933 variation from normal.....	+4.50	+1.82	+1.12	-3.95	-1.55

increased amount of snow removal because of the necessity of keeping roads and streets open for automobile and truck traffic, becomes the controlling one and as a result more difficulty was encountered in certain cities in New Hampshire and Maine in the past winter than in '17 and '18.

In some cities, and this is true in all districts, the situation was

complicated by factor *e* because of the carrying on of CWA work. In many places, street grades had been lowered leaving only a shallow cover over mains and services and in other places, sewer trenches were left open exposing water services while a delayed allotment of Federal funds was awaited to carry on the work.

In general, the same type of comparative conditions prevailed in the Albany and New York districts and in the southerly portion of central and eastern Pennsylvania as was the case in the Boston district. The temperatures averaged lower over the three months in the first of the two periods and the lower temperatures were present in December and January to an even greater extent than in February, while, of course, in the past winter the opposite was true; the snowfall was less during the '17-'18 period and the total precipitation during the fall months less in 1917 than in 1933.

In the general vicinity of Pittsburgh and Buffalo two of these three factors were contrary to the third. While here also the low temperatures were more sustained in the earlier period, the snowfall was very much less and the fall precipitation somewhat less in the past season. This situation, combined with a greater degree of snow removal and the adverse effects of the carrying on of various Federal projects resulted in more freeze-ups in the winter of '33 and '34. This was especially true in the vicinity of Oswego, New York, where a great amount of costly maintenance and replacement work was required. There was also an area including Williamsport, Pennsylvania, and northward and eastward where the almost complete absence of snow brought about such severe freeze-ups and such wastage of water that in certain small communities the higher parts of the territory served were without water for days.

Because of the character of the low temperature distribution during the past winter there were more meters frozen than ever before. The very low minimum temperatures broke all existing records in many places and therefore reached and froze meters whose settings had always before been well enough protected. On the other hand, the total excess pumpage of water was considerably less than in 1917-18 because the extreme cold did not start soon enough either to cause the longer period of pumping experienced in that year or to allow the habit of running water to prevent freezing to spread as widely.

In the larger number of cases during the past winter, frozen services occurred principally where they had been laid with less cover

than the regulation practice of the plant or where the cover had been cut by regrading. In the former period it was common practice for the street car plows to pile the snow high between the outer rail and the curb, thus adding to the cover, whereas with the widespread substitution of busses for trolley cars and the more common use of snow loaders trouble occurred unexpectedly in some places even though the controlling factors of temperature, snow and fall saturation of the soil would not have indicated it.

Immediately subsequent to the experience of 1917-18, the discussion of preparedness for the recurrence of such conditions was widespread, and the avowed purpose to lower shallow mains and services and to purchase engine driven generator outfits was commonly declared. Yet, as the years went on without an immediate recurrence, and, of course, as money to take these steps was always difficult for a superintendent to obtain, most operators gradually became forgetful of the rigors of that terrible winter and had it not been for a development of equipment entirely without the province of the water works man, we would, this last winter, have been as badly off as if the previous lesson had never been learned. It so happened, however, that the modern and more or less common welding outfit has the voltage and amperage range which is required for the average service thawing job and these engine driven generators were largely available and saved the situation for many plants.

#### THAWING EQUIPMENT

The most rapid and economical method of thawing is by the use of electricity. The most commonly used form of electrical thawing is to get the local power company to mount transformers on trucks and to connect to existing power lines in the streets. The cost of this method is apt to be greater than the use of other types of equipment, but there was usually not time to get other equipment after the freeze-ups began. In outlying districts no power lines were available in some cases, and other methods had to be resorted to. Engine driven generator sets especially designed for the purpose were occasionally available, but the modern welding outfit was found to have approximately the voltage and amperage range required for thawing services, and where these outfits were used for thawing mains two of them were used in parallel.

A third type of electrical equipment which is effective for short services where connections close together could be made was a small

portable transformer with a capacity of about 150 amperes at 20 volts. In some plants a surprising number of services were successfully thawed with equipment of this type plugged into house wiring.

Where only a few frozen services were encountered or where electricity was not available or where it was ineffective due to rubber gasketed couplings, new lead substitute joints in the intervening main pipe, or lack of capacity to thaw copper services, steam and hot water were used.

Steam is effectively used by generating it in a small portable boiler and feeding it under about 10 pounds pressure through a  $\frac{1}{8}$ -inch copper tube or  $\frac{3}{16}$ -inch Block tin tubing. It is successful only in relatively short straight pipes where the steam jet can be advanced against the ice as it melts. Where sharp bends are encountered and the tube cannot be advanced, the steam will not carry forward through the melted ice. Also, if the length of the service is too great the steam condenses before reaching the end of the tube and is not effective. This type of equipment has the advantage of being handled and operated by one man.

Hot water is, in general, more satisfactory than steam, although it requires two men to operate the equipment—one to push the tube into the pipe as the melting of the ice advances, and the other to operate the small force pump required. This method can be used on a longer service and the hot water will carry farther beyond the end of the tubing when it meets an obstruction than does steam.

Small sections of 4-inch main about 75 feet in length can be thawed by this method and if  $\frac{3}{8}$ -inch iron pipe is substituted for the copper or tin tubing, the length that can be thawed can be approximately doubled. Where relatively new lead substitute joints are encountered, preventing the use of electricity, this becomes a valuable method of thawing mains.

Experiences during the past winter indicate that the time required for thawing services by all three methods varied through a wide range. Where proper capacity was available for electric thawing, services were often thawed in from 3 to 10 minutes and small mains in from one-half to two hours. Both hot water and steam thawing require considerably longer time than this. However, in many instances, because of lack of experience and precedent, many jobs of thawing of both long services and mains were attempted without adequate equipment and, as a result, two or three hours were often spent on a service and as long as ten or more hours on a main.

*Electric thawing*

The cost of electric thawing was made up of many combinations of charges. In cases of hook-ups with the local power company, the charge was sometimes a stated amount per service or an hourly charge for all time and equipment with or without a current charge. Welding outfits were both on a per service basis and an hourly charge for men and equipment. The cost commonly varied between \$2.50 and \$7.50 per service for electric thawing, and hot water and steam also came within this range. A common charge for welding outfits was \$4.00 per hour, although it varied from \$2.50 to \$7.50 per hour.

One of the principal difficulties encountered in thawing by electricity is the occasional inability to get a closed circuit that will carry sufficient current to produce the required heat. The most common cause of this type of trouble is the presence of lead substitute joints in the section of main between the frozen service and whatever point is used for the second connection. The weight of evidence from past experience appears to show that new lead substitute joints definitely will not carry sufficient current for thawing. Depending somewhat upon the character of the water, joints of this type in about five years will have formed, by corrosion of the iron in the bell and the material itself, a contact that will carry electricity. This contact is somewhat fragile, however, and if too large an amperage is forced through it, it may burn through and break the circuit, after which other means than electricity will have to be used. To avoid this, it is necessary to keep the amperage below 200 or even 150 and keep the current on for the required extra time. Rubber bushed repair couplings are another reason for being unable to get a closed electric circuit, and, except in rare instances, time does not seem to produce a satisfactory current carrying contact unless much higher voltage is available than is needed for ordinary thawing work.

Failure to ascertain that there is no other path for the current to take may lead to failure in thawing, although the ammeter indicates that the proper amount of current is flowing. In some cases the current has taken a path through the house wiring and has heated the small wires and BX cable carrying them hot enough to set the house afire. It is not sufficient merely to detach the ground wire that is customarily found near the cellar wall, as other ground connections may be present elsewhere, and a complete disconnection of

the piping system by removal of a fitting or the meter is the only safe course.

Another trouble sometimes arises due to a poor contact at some joint in the main and so much current goes through a small area that the jointing material is melted out and a water leak results. Bad tastes and odors in the water after thawing are frequently encountered. Where lead substitute joints are in the circuit, the taste may be like sulphur, but tastes have also been reported where the joints are of lead. Dirty water apparently resulting from loosened tuberculation has been noted. This is more apt to occur where AC current is used as a perceptible vibration results from the cycle reversal of direction of the current flow.

The thawing of services and mains by the use of electricity will be more uniformly successful if water works operators will bear in mind the fundamental characteristics of current flow and energy transference. Amperage is the measure of quantity of current flowing and is the most important element to consider, because on the one hand the heating effect desired is principally dependent upon the flow of a sufficient number of amperes of current and, on the other hand, damage to joints and pipe is caused by too great an amperage. Voltage is the measure of electric pressure which is driving the current through the pipe. Voltage is therefore important only because of the amperage which it will force through the resistance of the pipe and joints. Ohms are a measure of resistance which is electric friction. The relation between the three is expressed as Voltage equals Amperage times Ohms. Thus, the greater the resistance, the greater must be the electric pressure to force through a given amount of current.

Resistance, therefore, if it be in the joints, is a detriment to current flow and to the thawing. But the resistance of the material of the pipe to be thawed is useful in thawing, for ultimately it is the heat produced which melts the ice, and the greater the resistance, the greater the heat produced by a given amount of current.

The transference of electric energy into heat in a conductor takes place according to a law first stated by James Joule, an English physicist. According to this law, the heat produced is directly proportional to the resistance of the conductor, the square of the amount of current and time the current is flowing. Thus it will be seen that a material which is a poor conductor and offers greater resistance to current flow will get hotter than one which is a good conductor.

Also, a relatively small increase in amperage will greatly increase the heat produced as the variation is as the square of the amperage increment.

It would appear from this law that any difficult job of thawing could be done by merely continuing the current flow for a long period and to some extent this is true, but it must be remembered that the heat produced in the pipe is immediately dissipated by the ice inside and the cold soil on the outside. Therefore, for any rate of heat production there is a point reached where it is dissipated as fast as produced and if in a reasonable time the pipe line is not thawed, it is safe to conclude that too much of the heat is being lost through the soil and mere continuance of this condition for a longer time will not be successful and that more heat must be provided. As the resistance of the pipe cannot be controlled, increased amperage is needed. And again, as the pipe resistance remains constant, additional amperage can be gotten only by increasing the electrical pressure or voltage.

As a result of Joule's law, it can be seen that a copper pipe, being a good conductor, can only be heated by passing a considerable amperage through it and for a longer time than in the case of other materials not such good conductors. The resistance of the various metals used for water pipes is relatively, using copper as 1; steel, 7; wrought iron, 9; lead, 12; and cast iron, 73. As copper has  $\frac{1}{7}$  to  $\frac{1}{9}$  the resistance of steel and iron and  $\frac{1}{12}$  that of lead, it is necessary to use at least twice the amperage and approximately twice as long a time in order to thaw the same length of service pipe of the other material.

Experience has shown that from 200 to 400 amperes, varying with the diameter, will thaw iron, steel or lead services in from three to ten minutes. Depending upon the character of the connections, the type of joints in the mains and other elements of resistance, the voltage necessary to force through such a current flow will vary from 10 to about 60 volts. To thaw mains, amperages of from 400 to 700 are apt to be required. Fortunately, in view of the larger area of metal in these pipes, cast iron has high resistance to current flow, else it would be impossible to produce sufficient heat with any practical portable apparatus.

To produce a current of 400 amperes at 60 volts requires about a 25 k.w. generator, although one with a capacity of 30 k.w. is better. The gasoline engine driving it should have a rated capacity of at

least 50 percent more to be able to sustain the output for several hours in the case of difficult main pipe thawing.

If current is taken from the 2300 volt lines of the local power company and stepped down to 110 volts, the transformers should have at least a total of 75 KVA of capacity if mains are to be thawed because it is occasionally necessary to use higher amperages than the averages stated and to maintain the current flow for several hours. A 25 KVA transformer is usually ample for the thawing of services. It has been observed that AC current is more effective than DC in thawing because the vibration set up by the former is of material aid as the necessary small amount of melting near the pipe surface takes place with a considerably less amount of actual temperature rise in the pipe.

It is to be hoped that water works operators will take more to heart the lessons learned during the past winter and will not again be lulled into a feeling of false security if such conditions are not met with again in the next winter or two. The delay caused by gathering the necessary equipment is both costly and undesirable from the viewpoint of giving good service. Furthermore, there should be some thought given to standardization of methods of charging consumers for thawing services. At present there is the greatest possible variation in this respect and many water departments and companies have not been consistent in their individual practice. Before another such winter arrives, thawing equipment should be purchased or definitely located and arranged for, and each plant should have its organization trained in the work so that the delay and confusion experienced last winter will be eliminated, and rules and regulations should be redrawn to provide for whatever method is decided upon for defraying the cost of the work.

### DISCUSSION

C. A. HOLMQUIST<sup>1</sup> AND A. F. DAPPERT:<sup>2</sup> During the very severe winter of 1934 unusual numbers of frozen water pipes were quite generally experienced throughout the state. Water works officials were called upon to work many extra hours, in some cases frantically, responding to the emergencies thus created. Because of the wide-

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spread conditions, the frequent calls made upon the Department for advice and assistance, and general interest in the subject among water works men from all sections of the state steps were taken to accumulate information regarding the various experiences encountered in the many municipalities so that such information could be made available to all. To this end questionnaires were sent to most water works officials in the state. The replies to these have contributed considerable information and subsequent correspondence has added much of value. The State Department of Health would here like to express its appreciation to the water works officials of the state for their full coöperation in responding to requests for information. The following discussion summarizes the data thus obtained and gives some of the more interesting "high-lights" of the various experiences reported.

#### COLD WEATHER CONDITIONS

It will be recalled that January, February and March were unusually cold months. The average of the mean monthly temperatures for these three months ranged from 12.4°F. in the St. Lawrence Valley and Adirondack sections to 27.9°F. in the Atlantic Coastal section. Many sections were repeatedly visited by prolonged periods of cold temperatures, in some instances reaching 40 to 50 degrees below zero. The lack of snow in some sections aggravated conditions. In many localities the ground became frozen to depths of 5 feet or more. The very severe conditions that prevailed generally throughout the state, together with the rather universal experience with reference to the freezing of water mains, hydrants and services, will make 1934 a year long to be remembered by the water works officials in this state.

#### DAMAGE DUE TO FREEZING

It is not possible to estimate accurately the amount of damage caused by the widespread freeze-ups throughout the state, but it is safe to say that it amounted to many thousands of dollars. In a few instances entire supplies became frozen and residents were without service for many days. In several instances expensive temporary lines had to be laid. Some of the very small municipalities reported actual damages in excess of \$5,000. The repairs to broken mains and hydrants and house services in many cases amounted to considerable sums.

Replies were received from 306 municipalities, of which 147 reported frozen mains, 117 broken mains, 93 frozen hydrants, 63 broken hydrants, 251 frozen service pipes and 184 broken service pipes. Service pipes, as would naturally be expected gave the most trouble, although in many municipalities there were numerous breaks in mains. Buffalo alone reported 50 broken mains. One hundred eighty-one municipalities reported a total of nearly 10,000 frozen services.

#### RELATION OF DEPTH OF COVER TO FREEZING OF WATER PIPES

The following tabulation shows in a general way the relation of depth of cover to the freezing of water pipes.

DEPTH OF COVER, FEET	NUMBER OF SYSTEMS WITH MAINS LAID AT DEPTHS INDICATED	NUMBER OF SYSTEMS WITH FROZEN MAINS	NUMBER OF SYSTEMS WITH SERVICES LAID AT DEPTHS INDICATED	NUMBER OF SYSTEMS WITH FROZEN SERVICE PIPES
Less than 3	2	2	4	4
3 to 4	37	21	47	44
4 to 5	159	73	159	137
5 to 6	102	47	90	62
6 to 7	5	3	3	3
More than 7	1	1	1	1

From the foregoing it will be noted that trouble was quite generally experienced regardless of the depth of cover. However, in several instances where deep depths of cover were reported for mains or services, notation was made on the questionnaire that the freeze-up occurred in a section where some time subsequent to the laying of the pipe the street grade had been cut down, thus reducing the depth of cover. It is apparent from a careful review of the questionnaires that, generally speaking, many services were frozen even though the depth of cover was as much as 5 and in some cases 6 feet. This is not surprising when it is recalled that in many sections of the state at the time the frost line was reported to be from 5½ to 6 feet deep, or more.

#### INCREASED USE OF WATER DURING SEVERE COLD WEATHER

The period during which difficulties were experienced with frozen water pipes varied considerably from about two weeks up to two and one-half months. The average period of difficulty as calculated

from the replies was about one month. During this period water consumption in most municipalities was considerably in excess of the normal, being increased in several instances to more than 100 per cent above the normal. A few municipalities, however, reported decreased water consumption during the period. In a good many communities, residents were instructed to leave faucets run and hose connections were made to dead ends to prevent freezing. This practice, which was somewhat general, together with the leaks which developed would account largely for the great increase in water consumption that was generally reported.

#### METHODS OF THAWING PIPES

The replies indicated that the electrical method of thawing was the most popular and generally the most satisfactory, especially on frozen services. However, many municipalities found it necessary to resort to wood, coke or charcoal fires, or the use of steam for thawing mains. The use of salt and blow torches and steam on hydrants was frequently reported.

In 67 percent of the municipalities reporting, the electrical method was used exclusively. The majority of these relied upon the service furnished by local power companies, although a good many purchased their own equipment. In a few cases the necessary apparatus was constructed and assembled locally. Forty-six municipalities reported the purchase of new commercial type equipment, most of which was of the electrical type.

In 23 percent of the municipalities reporting, various combinations of thawing methods were used. For the most part, in these municipalities electrical equipment was used on services, sometimes in conjunction with hot water or steam, and steam, hot water, blow torches or wood fires were used on frozen mains.

Five percent of those reporting used steam, 4 percent fires and torches, and 1 percent hot water exclusively.

#### COST OF THAWING

From the replies received it appears that a total of more than \$125,000 was spent in the aggregate for thawing, exclusive of the purchase of new equipment in the municipalities which reported. The costs for equipment varied greatly, ranging from a steam apparatus costing \$35.00 used in one Long Island village to \$1225 for a high capacity electrical thawing outfit used in one of the northern

villages. Several municipalities used moderate capacity electrical outfits costing about \$500.00. The majority of the electrical outfits purchased by municipalities during the winter, however, ranged between \$150 to \$250 in cost. Where thawing service was procured through local power companies, it is believed that rather high capacity outfits were employed.

In 48 percent of the municipalities reporting, the property owners paid for the cost of thawing water service pipes; in 27 percent the cost was borne jointly by the municipality and property owner; and in 25 percent the municipalities thawed services without charge to the property owner.

Where equipment was rented the charges varied from \$2.50 to \$15 per hour. Where a set price per service was established, \$5.00 was a frequent charge, although in many instances charges of \$10.00 or more were made.

The costs for thawing services averaged \$8.50, but varied from \$2.00 to \$50.00.

Generally the cost of thawing by steam, hot water or wood fires was reported to be greater than by electricity, particularly on house services.

#### DIFFICULTIES IN THAWING BY ELECTRICITY

The reports from various municipalities would indicate that electrical thawing has been generally satisfactory. The replies from 143 municipalities, in the majority of which thawing service was provided by local power companies, would indicate full satisfaction with electrical thawing, except perhaps with respect to the variable rates charged by the power companies for this service. Municipalities that purchased commercial equipment report, in general, that satisfactory results were obtained. The instances where such equipment has failed to work have apparently been where the thawing jobs were beyond the rated capacities of the outfits, or where the thawing of copper service pipes or pipes jointed with hydrotite or leadite was undertaken with outfits of too low capacity.

Although a number of municipalities reported difficulty in thawing pipes with leadite or hydrotite joints, it is believed that this was due to the use of rather low capacity thawing outfits since there were several municipalities with medium and large capacity outfits which reported no difficulty in thawing pipes with such joints. Generally speaking, when thawing was done by outfits supplied by power com-

panies, which presumably have of adequate capacity, little difficulty was reported. Where such joints are bonded, as at Mechanicville, no difficulties are encountered in securing a flow of current.

The development of some tastes following the thawing of both copper services and pipes using joint compounds was rather generally reported, but it is felt that this experience is of no great significance as most of the tastes could be eliminated in a few hours by thorough flushing.

In one instance it was reported that electric thawing burned out all hydrant packings. In another instance the superintendent attributed leaky hydrants following electrical thawing to the use of the hydrant as a terminal.

In a good many cases leaks or breaks are reported to have occurred either during or immediately following the thawing process. Several instances were reported where rusty water with a musty taste developed after thawing, which was attributed to the removal of tubercles from the mains.

Some municipalities reported that lead joints were affected and in some cases melted. One municipality reported in every instance following electrical thawing of service pipes a break developed about the middle of the pipe. One municipality reported that generally breaks occurred in the goosenecks between the mains and services. Another reported that in 9 out of 10 instances where services were thawed electrically breaks occurred in the lead goosenecks, leaving holes about the size of a silver dollar.

Considerable difficulty was also reported in the electrical thawing of copper service pipes due to high conductivity and heat losses through the copper pipe into the surrounding soil. Generally the thawing of copper service required a longer time for thawing than galvanized iron or required increased current.

One municipality reported that it was necessary to develop 1500 amperes to thaw out some pipes.

In one municipality the practice of attaching a piece of copper tubing to the corporation stop on the main and carrying it to the surface as a future electrical connection was followed in all cases where it was necessary to dig during the past winter to make such connections. This practice was recommended by another municipality as a future policy in case of all new services and replacements.

## SUMMARY

The reports from the various municipalities would indicate that electrical thawing methods proved generally satisfactory. The replies in the aggregate comprise a good testimonial to the successful use of electric thawing equipment. The evidence appears quite plain, however, that copper service pipes are difficult to thaw and that where leadite or hydrotite joints are in use, electrical thawing may not be attended with success unless adequate capacity outfits are employed.

It is interesting to note that in many municipalities where excellent results were obtained in the electrical thawing of service pipes, steam or wood fires were used for the thawing of frozen mains. This would suggest that in many instances the electric thawing outfits were of too small capacity to work effectively on larger size pipe.

The logical conclusion that may be inferred from the various experiences recorded is that electrical thawing outfits will operate with degrees of success about in proportion to their capacities. The very small capacity outfits will apparently work satisfactorily on small lengths of iron service piping but are generally unsatisfactory for use on copper services. Medium capacity outfits will operate successfully on larger lengths of pipe, including short lengths of small size mains and generally on copper services. High capacity units generally will work satisfactorily on mains of considerable lengths, on copper services and on pipes jointed with leadite.

Because less difficulties were reported from municipalities which procured thawing service from local power companies, it is considered that best results will be obtained when electrical thawing is under the supervision of a competent electrician. The work requires at least supervision by someone who is familiar with the making of electrical connections, who understands thoroughly the principles involved and who can arrange hook-ups that will avoid current losses. Notwithstanding this, very good results were obtained in many instances by inexperienced men who were intelligent enough to follow the equipment manufacturer's directions.

In selecting electrical thawing equipment, consideration should be given to the size and lengths of piping and the pipe materials that will probably have to be thawed. If electrical thawing of services only is contemplated, then a lower capacity outfit will be needed than if thawing of mains is contemplated. Furthermore, it is believed

to be generally advisable to provide an outfit with variable output so that power requirements can be adjusted for the particular conditions. With outfits which have fixed outputs, the job has to be fitted to the machine rather than the machine to the job.

The following list of firms were reported to have furnished thawing equipment to New York State municipalities this year:

- W. S. Darley Company, 2810 Washington Boulevard, Chicago, Ill.
- The Engesser Manufacturing Company Inc., Watertown, N. Y.
- The Chautauqua Electric Motor and Repair Company, Jamestown, N. Y.
- General Electric Company, Schenectady, N. Y.
- The Westinghouse Electric Company, Pittsburgh, Pa.
- Ezra R. Fern Sons, 1130 Mulberry Street, Scranton, Pa.
- The Lincoln Electric Company, 357 Bruce Street, Syracuse, N. Y.

## MILWAUKEE'S WATER PURIFICATION PROBLEM

BY JOSEPH P. SCHWADA

(*City Engineer, Milwaukee, Wis.*)

One of the most important problems in the City of Milwaukee is that of safeguarding and improving the quality of its water supply. This is being solved at the present time by the construction of a water purification plant of the rapid sand filtration type to treat water taken from Lake Michigan. Ordinarily such a problem and the building of a water purification plant creates no unusual interest, because of the conditions and features involved, the water supply being highly polluted, or highly turbid at all times, or the taste and odors extremely offensive. Under such conditions the necessity for purification is so obvious that public opinion demands immediate improvements and a plant is speedily constructed. However, where a water supply is of satisfactory physical and bacterial quality for a considerable proportion of the time, although subject to lapses, then indeed is it difficult to convince the public that a water purification plant is necessary for the health, comfort and convenience of the people. This latter condition has been the situation in Milwaukee, where since 1911 a plant has been considered and periodically recommended by sanitary engineers, and regularly opposed by some of the consumers. The situation in Milwaukee, therefore, has created more than the usual interest, and with this in mind, this discussion will present the problem and the investigation, studies and educational campaign which led to its ultimate solution.

### HISTORICAL

The City of Milwaukee has followed the practice of discharging sewage and industrial wastes into the three rivers passing through it and thence into the lake, from which its water supply is taken. In due time this practice caused the rivers to become highly polluted and offensive to smell, and the water in the bay unfit for human consumption. When in 1909 this condition became unbearable, the Common Council authorized a commission of sanitary engineers consisting of John W. Alvord, George C. Whipple and Harrison P.

Eddy, to make a comprehensive study of sewage disposal and to investigate the city's water supply. This commission presented its report on April 25, 1911. It outlined and recommended the building of a sewage disposal system, but pointed out that even with such a system "some sewage will inevitably reach the rivers, especially in times of storm, and the effluent from the sewage disposal works will cause some bacterial contamination of the waters of the bay and will at times endanger the water supply." This commission therefore recommended "That a filter plant be provided for the purification of the water supply, construction to be begun immediately."

In the same year, 1911, an investigation of the water supply was made by Doctor A. J. McLaughlin of the United States Public Health Service and the conclusions reached were: "What Milwaukee needs immediately is filtration or treatment of the public water supply." . . . "The proposed sewage disposal scheme in Milwaukee, while making conditions infinitely better from the standpoint of nuisance, does not and cannot remove the menace to an untreated or unfiltered water supply."

In 1917, following a severe typhoid epidemic, Sanitary Engineer, H. P. Letton of the United States Public Health Service made an investigation and the city was advised to construct a filtration plant, and that in no other way could Milwaukee be furnished a safe and palatable supply of drinking water.

In 1920, the City engaged Mr. Joseph W. Ellms to make an investigation and conduct an experimental filtration plant. Mr. Ellms' experiments extended over a period of about one year and as a result he found that the water from the lake could be successfully filtered, and that the best and only safeguard for its purity was filtration.

The recommendations of Mr. Ellms precipitated a controversy, and in 1921, Sanitary Engineer R. E. Tarbett of the United States Public Health Service made an investigation and recommended the city proceed with plans for installing a filtration plant along the lines recommended by Mr. Ellms.

Following this report, Mr. Harrison P. Eddy was called in and in June, 1921, advised the city that it should provide a filtration plant, and that the plant should not be delayed to await the results of the treatment of sewage, as had been contended by the opponents of filtration. It should be pointed out too that Mr. Eddy was serving the Milwaukee Sewerage Commission in the capacity of consulting engineer when this advice was given.

Again in 1931, the City sought further advice and received another report from Mr. Eddy in which he stated: "Filtration of the water is necessary for its purification and the city should provide forthwith a water filtration plant."

Following this report, the United States Public Health Service was again called upon. Mr. H. W. Streeter, of that Service, made an investigation, and in March, 1931, advised the city to take steps to insure a wholesome water supply, that the steps should be undertaken as soon as practicable, in order to avoid a probable overburdening of the present chlorination system in the event of one or more years of excessive rainfall, or of unusual storms, and that they should be completed, if possible, by the year 1935.

#### OPINIONS OF SANITARY ENGINEERS UNANIMOUS

Thus since 1909 the city has had this problem of water purification definitely before it and has repeatedly sought expert advice. However, in spite of the unanimity of opinion among the various engineers during the past twenty-two years, that a filtration plant was needed for safeguarding and improving the quality of the water supply, the necessity was continually questioned and the building of a plant opposed, primarily by some of the larger water consumers. Even after the Public Service Commission of Wisconsin granted the city a certificate of convenience and necessity in 1933 the question was carried into the courts where it was finally disposed of in favor of the City.

#### SOURCE OF WATER SUPPLY—LOCATION OF SEWAGE DISPOSAL PLANT

The City of Milwaukee obtains its water supply from Lake Michigan through an intake tunnel 6,553 feet long extending northeasterly out into the lake from a point near the north side of the city (see figure 1). The depth of the lake at the crib is 67 feet and the crib is located about five miles from the Sewage Disposal Plant, and about four miles from the outlet of the harbor. Attention is called to the breakwater with its several openings through which pollution from the rivers and the Sewage Disposal Plant passes out into the lake.

#### *Sources of pollution*

There are several sources of pollution which have an influence upon the quality of the water supply and make it potentially dangerous. One of these is the by-passing of untreated sewage and industrial

wastes from the intercepting sewers into the rivers, and from the sewage disposal plant during times of heavy rainfall.



FIG. 1. LOCATION OF SEWAGE DISPOSAL PLANT, WATERWORKS INTAKES AND BREAKWATER

The City of Milwaukee has a combined storm and sanitary sewer system over 61 percent of its area (see figure 2). This combined

system is connected to the intercepting sewers that conduct the sewage to the disposal plant. The remainder of the Metropolitan

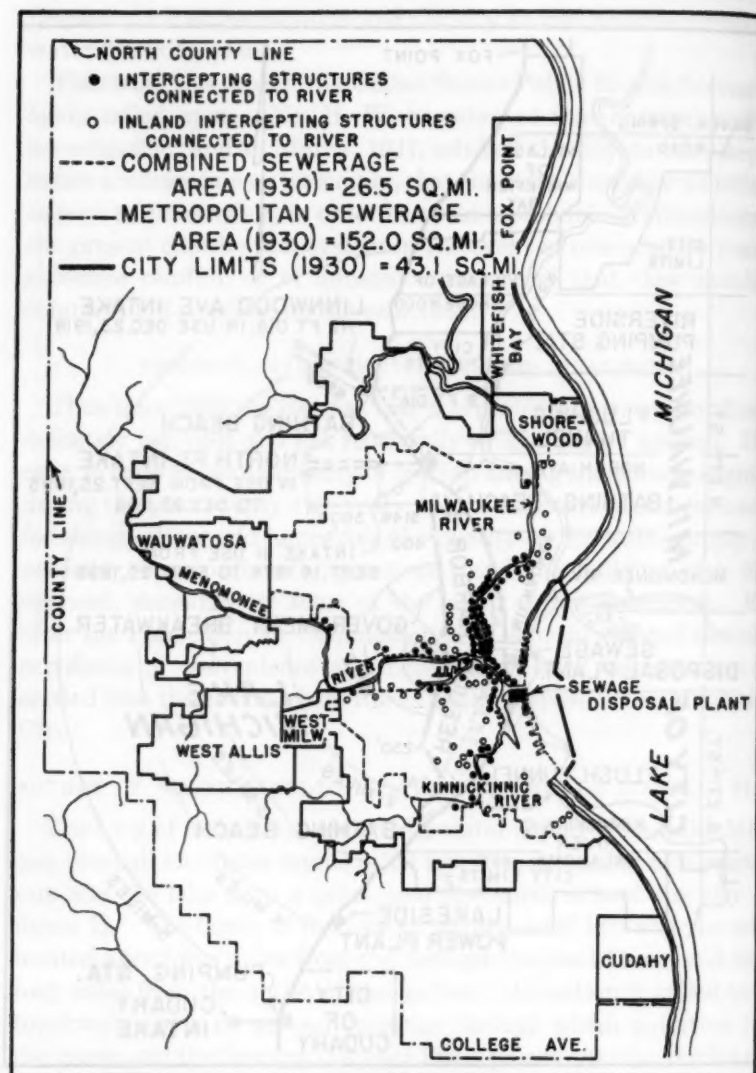


FIG. 2. LOCATIONS OF IMPORTANT SANITARY STRUCTURES

District has separate systems for the sanitary sewage and the storm water, with the sanitary system connected to the intercepting sewers and the storm sewers connected to the rivers.

The intercepting sewers which conduct the sewage to the disposal plant were built of a capacity to carry the dry weather flow, and the initial storm runoff. These sewers could not economically be built large enough to carry all of the storm water in addition to the dry weather sewage, and so in times of heavy rainfall it is necessary to by-pass combined storm water and sewage over intercepting dams into the rivers. As shown in figure 2 there are about 85 such overflow locations or connections to the rivers.

It is also necessary periodically to by-pass untreated sewage combined with storm water at the sewage disposal plant, in order to maintain the quality of the activated sludge and the proper balance in plant operation.

In addition to the sewage by-passed into the rivers and lake as above described, it is of interest to note that with a 95 percent bacterial removal at the sewage plant, additional pollution of the lake is caused by the remaining five percent of the bacteria from the sewage treated. This, in itself, is equal to all the sewage from a population of about 40,000 persons.

Then, too, there is the pollution from the streets, and from the yards and farms over the entire drainage areas of the three rivers which eventually finds its way into the lake. All of the pollution, including the effluent from the sewage disposal plant, is discharged into the inner harbor and under favorable conditions is carried out into the lake through the several openings in the breakwater, and, naturally must have some effect upon the quality of the water in the lake.

#### *Pollution reaches intake*

In order to determine the effect of the pollution upon the quality of the water, a comprehensive qualitative survey of the water in the lake was made over a period of several months in 1928. In this survey samples of water were taken daily at several spar-buoy locations on the lake (see figure 3), including a station at the end of the North Point intake, which intake is not in use at the present time. This latter station was included to determine the quality of the water that would enter this intake in the event it was again used.

Early in the work it was found that on certain days the water at the several stations was relatively good, and on other days highly polluted. It was also found that the density of pollution at any station varied, and at times became worse over a period of days. It

was furthermore noticed that rainfall and the by-passing of sewage had an influence upon the quality of the water, and, it was suspected too that the winds likewise had an influence.

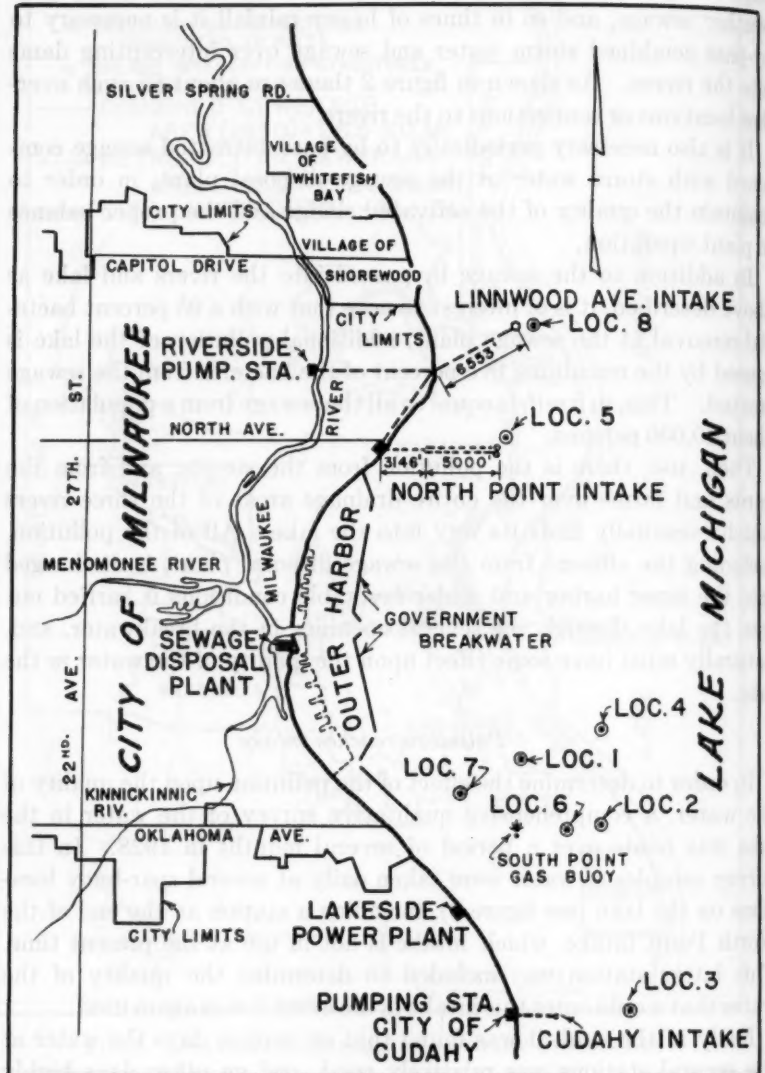


FIG. 3. MILWAUKEE WATERWORKS—NEW INTAKE INVESTIGATION, 1928—  
MILWAUKEE BAY BUOY LOCATIONS

A day-to-day study was then made of the relation between these factors, and a chart was prepared similar to figure 4, on which was shown the time and amount of rainfall, the time of sewage by-passing at the disposal plant, the direction and velocity of the winds, and the pollution in the water at the several stations, as determined from the daily samples. This day-to-day study was later expanded to include the quality of the water entering the Linnwood Avenue intake during the years 1928, 1929 and 1930 as determined from the laboratory records.

This study definitely established the fact that these several factors did have an influence upon the quality of the water in the lake, including the water entering the Linnwood Avenue intake. Appearance and density of pollution at the several stations were primarily dependent upon rainfall and the by-passing of sewage. The winds also had an influence upon the appearance and density of pollution at the several stations.

With reference to the raw intake water, a close inspection of the day-to-day changes in the quality of the water, in relation to prevailing winds, indicated that certain wind directions, notably a west wind followed by a southerly wind, appeared to be followed closely, in numerous instances, by an increase in the bacterial content of the raw intake water. Occasionally these increases were so sudden and severe that pollution could be clearly traced through the chlorination process to the treated water.

In the report of H. W. Streeter, Sanitary Engineer of the United States Public Health Service of March, 1931, who made use of the graphs prepared by the City Engineer's Office, he states as follows:

"In order to study systematically the influence of changes in wind direction, a tally was made of the number of times during the years 1928, 1929 and 1930, in which the daily maximum confirmed *B. coli* index of the raw water exceeded the arbitrary limiting value, 40 per 100 cc." . . . "In a total of 148 occurrences of this kind the following numbers and percentages of such occurrences associated with\* various wind directions were counted" (see figure 5).

"From these data (see figure 5) it appears that 118 out of the 148 occurrences, or about 80 percent of the total were associated with winds blowing from the west and from the three southerly points of the compass, southeast, south and southwest. Of these, 82 occurrences, or about 55 percent of the total, were associated with west and southwest winds. As the intake lies in a direction roughly northeast of the harbor mouth and as most of the

\*By "associated with" is meant either immediately preceding or, for a sustained wind, occurring coincidently with the bacterial increases noted.

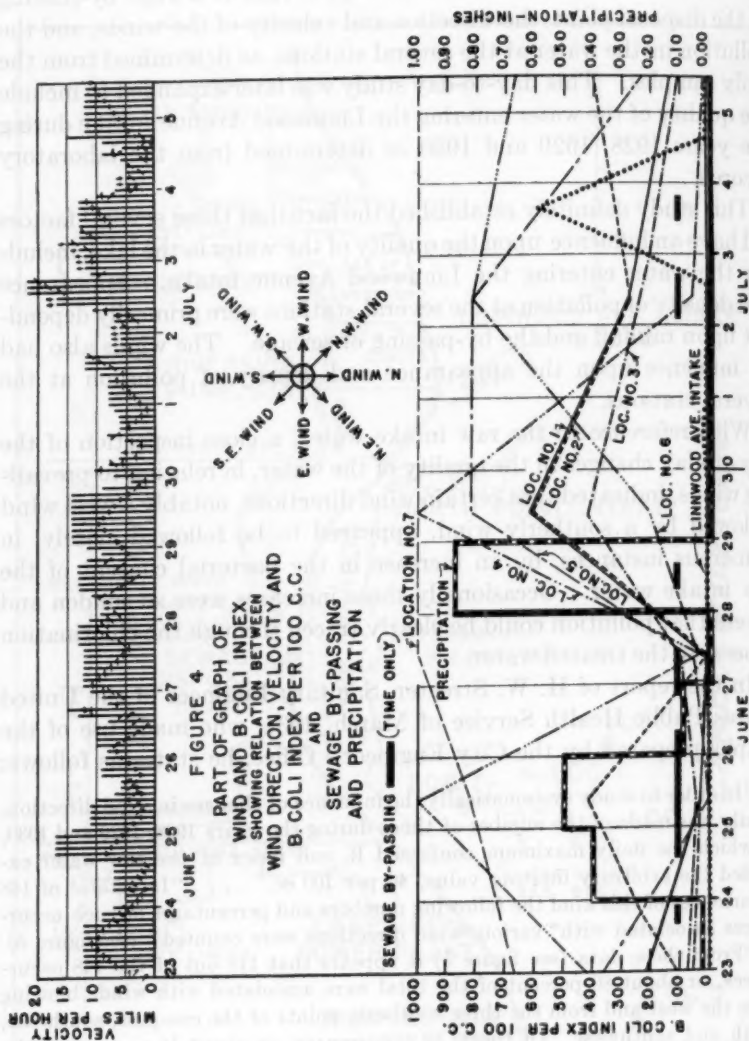


Fig. 4

pollution contributed by the Milwaukee area passes through the harbor, the course of such material in moving toward the intake would be expected to be governed largely by westerly and southerly winds."

"In order to determine the relative degree to which lapses in the quality of the treated water were associated with various wind directions during the same three-year period, a tally similar to that above described was made with respect to the wind directions associated with the appearance of *B. coli* in the chlorinated water at the North Point station." The results are also shown in figure 5.

"In this case, 69 percent of the appearances of confirmed *B. coli* in the treated water were associated with winds from the west, southwest, south and southeast, and 50 percent with winds from the west and southwest. Although these percentages would not be expected to agree very closely with those obtained from the corresponding analyses of the raw water data, the preponderance of lapses in the quality of the treated water associated with west and southerly winds appears to be highly significant, as indicating that these lapses may be traceable, in many cases, to pollution of the raw water brought to the intake by favorable winds from the polluted zone of Milwaukee harbor. It is further significant as indicating that a failure of the chlorination process to remove all of the *B. coli* from the raw water may be associated in many cases with the sudden and large increase in pollution of the intake water resulting from a combination of westerly and southerly winds."

In analyzing the day-to-day count it was found that the intensity of winds had an important bearing upon the appearance of *B. coli* in the intake water, and that intense winds or violent storms of short duration speedily carried pollution from the harbor out into the lake and to the intake, more so than winds of long duration and of low intensities.

Thus it is seen that the quality of the water is largely dependent upon climatic conditions, namely, rainfall, prevalence and intensity of storms, and winds that carry the pollution to the intake.

#### CHLORINATION SYSTEM

Since 1915 the city has been using liquid chlorine alone to sterilize the water, and in the operation of this system every reasonable effort is made to maintain as high a degree of efficiency as is practicable under the prevailing working conditions. Yet, in spite of this effort, *B. coli* is occasionally found in the treated water.

In figure 6 the average daily *B. coli* index is shown of the raw water and the daily chlorine dosage for the year 1929, a year of heavy spring thaws and storms on the lake. The *B. coli* index of the treated water for the year 1929 is shown in figure 10.

*Relation between direction of winds and occurrences of B. Coli with an index exceeding 40 per 100 cc. in raw water. 1928-29-30*

PREVAILING WIND DIRECTION	DAILY MAXIMUM B. COLI INDEX EXCEEDING 40 PER 100 CC.	
	Number	Percentage of total
North.....	7	4.7
Northeast.....	8	5.4
East.....	3	2.0
Southeast.....	21	14.2
South.....	15	10.1
Southwest.....	36	24.4
West.....	46	31.1
Northwest.....	12	8.1
	148	100.0

118 out of 148 occurrences or 80 percent associated with winds from the west and from the three southerly points of the compass, and 82 occurrences or 55 percent with winds from the west and southwest.

*Relation between direction of winds and occurrences of B. Coli in the chlorinated water*

PREVAILING WIND DIRECTION	APPEARANCES OF CONFIRMED B. COLI IN CHLORINATED WATER	
	Number	Percentage of total
North.....	10	10
Northeast.....	6	6
East.....	2	2
Southeast.....	13	13
South.....	6	6
Southwest.....	22	22
West.....	28	28
Northwest.....	13	13
	100	100

69 out of 100 occurrences or 69 percent associated with winds from the west and from the three southerly points of the compass, and 50 occurrences or 50 percent with winds from the west and southwest.

FIG. 5

The chlorine dosages applied to the water during the years 1928 to 1933 inclusive, are shown in the following table:

	CHLORINE DOSAGE IN OUNCES PER MILLION GALLONS					
	1928	1929	1930	1931	1932	1933
Minimum.....	24	32	32	36	40	40
Maximum.....	48	96	64	80	80	128
Average { N. P.....	38.0	45.2				
{ Riv.....	33.1	45.0	41.9	44.7	50.6	51.7

N. P., North Point Station; Riv., Riverside Station.

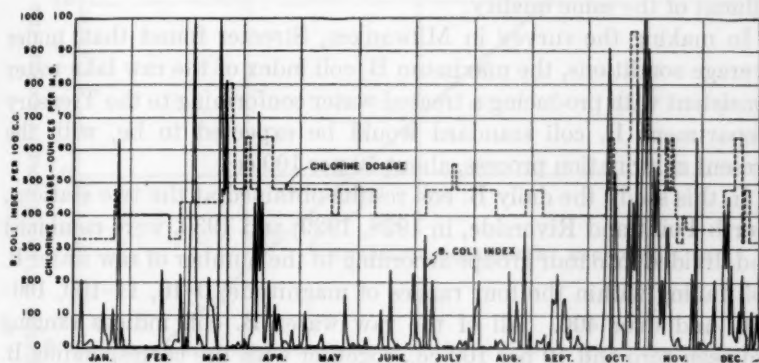


FIG. 6. RAW WATER B. COLI INDEX AND CHLORINE DOSAGE, 1929—DAILY AVERAGES

In applying the chlorine an effort was made to adjust the treatment according to the degree and variability of pollution of the raw water. This was not consistently accomplished. At times a sudden and large increase in the pollution of the raw water was obtained without warning, by changes in climatic or atmospheric conditions, and no increase in the chlorine dosage was made. At other times when conditions indicated a probable appearance of heavy pollution the chlorine dosage was increased, but the expected pollution did not appear. This experience clearly illustrates one of the weaknesses of treatment with chlorination alone, in Milwaukee, namely, the inability to adjust the treatment according to the degree and variability of the pollution of the raw water and thereby restrict lapses in the quality of the treated water within bounds of reason (see figure 10).

It may be of interest in this connection to note that this condition in Milwaukee is not unusual. Extensive studies made by the United States Public Health Service during the past few years have resulted in determining that on an average there is a limit to the effectiveness of chlorination in producing a treated water conforming to a given standard of quality. Where sufficiently reliable laboratory data are available, it is readily possible, by an analysis of the concurrent variations observed in the bacterial quality of the influent (raw) and effluent (treated) waters, to estimate the average limiting density of raw water pollution within which chlorination is able to produce an effluent conforming to a given standard of quality and beyond which, conversely, it may be expected ordinarily to fail in producing an effluent of the same quality.

In making the survey in Milwaukee, Streeter found that, under average conditions, the maximum B. coli index of the raw lake water consistent with producing a treated water conforming to the Treasury Department B. coli standard would be expected to be, with the present chlorination process, about 40 per 100 cc.

In this study the daily B. coli results obtained at the two stations, North Point and Riverside, in 1928, 1929, and 1930, were combined and divided into four groups according to the number of raw water B. coli falling within the four ranges of magnitude, 0-10, 11-100, 100-400, and over 400. All of the raw water B. coli indices ranging between zero and 10 per 100 cc., together with the corresponding B. coli indices recorded coincidently in the treated water, were placed in the lowest range group and both series of figures were totalled and averaged. The same procedure was repeated for the results falling into each of the three other groups. From this process of grouping and averaging the following results were obtained:

RAW WATER B. COLI INDEX RANGE PER 100 CC.	AVERAGE B. COLI INDEX PER 100 CC. IN:		PERCENTAGE OF RAW WATER B. COLI IN TREATED WATER
	Raw water	Treated water	
0-10	1.8	0.07	3.8
11-100	38.6	0.77	2.0
100-400	238.0	1.70	1.8
Over 400	644.0	17.0	2.6

An inspection of these results having indicated that an increase in the average B. coli index of the raw water has been accompanied by

an increase in the corresponding average *B. coli* index of the treated water, these figures were plotted against each other on logarithmic scales and a straight line fitted to the plotted points. The resulting plot is shown in figure 7.

In order to give a better idea of the actual numerical trend of the relationship indicated by the plotted line in figure 7, the lower portion

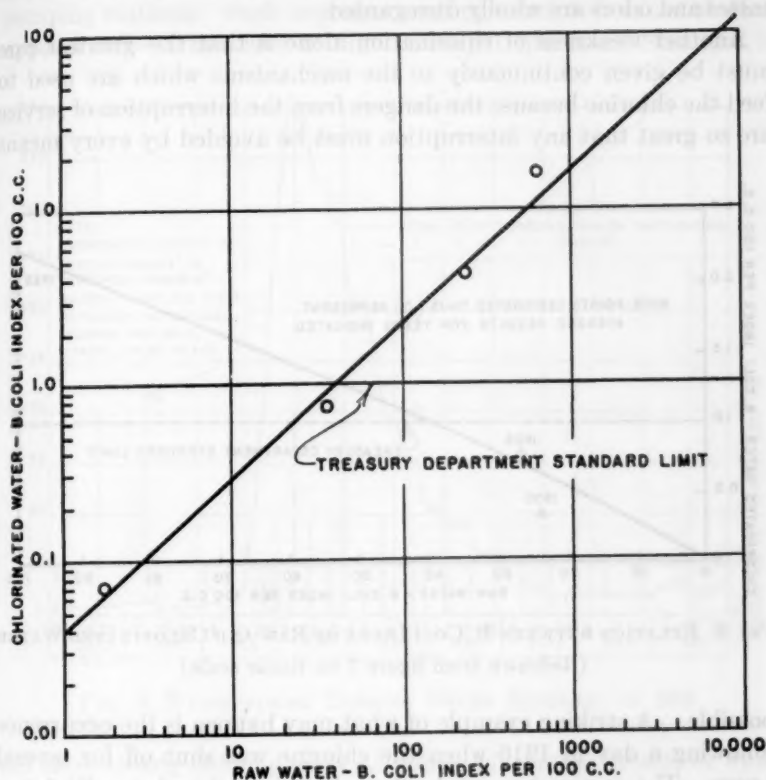


FIG. 7. RELATION BETWEEN *B. COLI* INDEX OF RAW AND CHLORINATED WATER

of it was redrawn, without the points, in figure 8 on linear instead of logarithmic scales. For comparison with this performance curve, the average *B. coli* results recorded in the raw and treated waters during the years 1928, 1929, and 1930, respectively, were plotted on the chart. The 1928 average was adjusted by eliminating from it an excessively high figure for February, which was due to abnormal results obtained on February 15th. With this single correction the

agreement between the curve and the annual averages for the three respective years is close.

The chlorination system in Milwaukee, according to the studies of the United States Public Health Service, has its limitations and does not produce a treated water that consistently conforms to the Treasury Department Standard. It cannot do so unless, of course, tastes and odors are wholly disregarded.

Another weakness of chlorination alone is that the greatest care must be given continuously to the mechanisms which are used to feed the chlorine because the dangers from the interruption of service are so great that any interruption must be avoided by every means

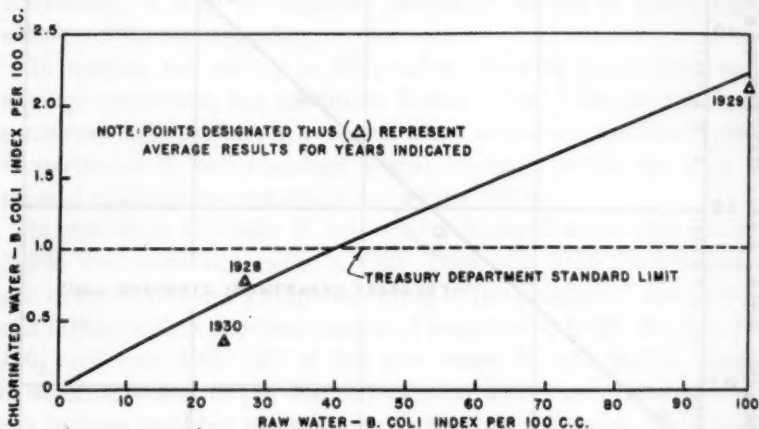


FIG. 8. RELATION BETWEEN B. COLI INDEX OF RAW AND CHLORINATED WATER (Redrawn from figure 7 on linear scale)

possible. A striking example of what may happen is the occurrence following a day in 1916 when the chlorine was shut off for several hours. The raw water was badly polluted on this day. Within a short time, 25,000 to 100,000 cases of diarrhea resulted followed by about 500 cases of typhoid fever and 60 deaths from typhoid fever.

This water-borne typhoid epidemic is shown in figure 9. The solid black line shows the variation in the number of typhoid cases on hand each day. The maximum number on one day was 255. The vertical lines show the number of deaths that occurred on various days and the full effect can be appreciated by a comparison with the conditions before and after the epidemic.

## QUALITY OF TREATED WATER DOES NOT MEET STANDARDS

In the controversy over the water purification plant the opponents contended that the quality of the chlorinated water had conformed to the Treasury Department Standards, and based such contentions upon the use of annual averages, and in some cases upon monthly averages of all the samples of water analyzed twice daily at both pumping stations. Such averages seem permissible because of what appears to be a weakness in the Treasury Department Standard in

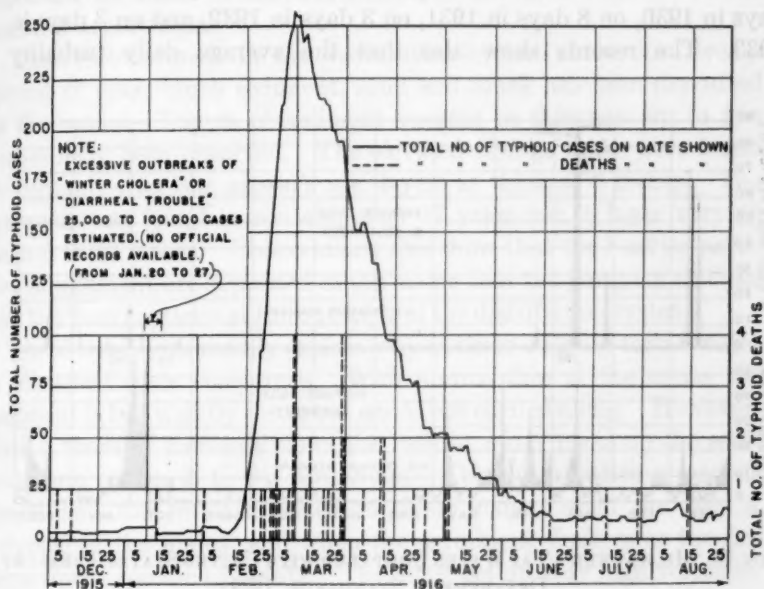


FIG. 9. WATER-BORNE TYPHOID FEVER EPIDEMIC IN 1916

not more clearly defining what a "series" of samples means, or what period of time must be considered in analyzing a series of samples.

The writer contended that averages are misleading and that the city should be concerned with the quality of water over a period of time which would be sufficient to cause an epidemic if the water were polluted with pathogenic germs. When averages are used, high peaks of pollution may be practically eliminated and so overshadowed as to leave the incorrect impression that the tap water has been of good quality at all times.

In figure 10 is shown a comparison of the tap water in the year 1920

with the United States Treasury Department Standards. The upper portion of the figure shows that the average daily B. coli index of the tap water exceeded the standard index of 1 per 100 cc. on various days. The lower portion of the figure shows the average daily turbidity in comparison to the standard. The year 1929 is used here because this was a year of heavy spring thaws and storms on the lake.

The records show that average daily B. coli index of the tap water exceeded the standard on 17 days in 1928, on 20 days in 1929, on 15 days in 1930, on 8 days in 1931, on 3 days in 1932, and on 3 days in 1933. The records show also that the average daily turbidity

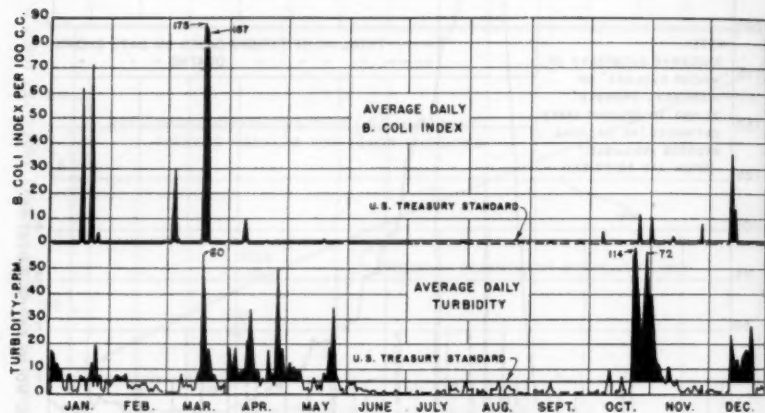


FIG. 10. MILWAUKEE'S TAP WATER COMPARED WITH UNITED STATES TREASURY DEPARTMENT STANDARDS, 1929

exceeded the standard on 74 days in 1928, on 121 days in 1929, on 14 days in 1930, on 21 days in 1931, on 54 days in 1932, and on 105 days in 1933. The records therefore show that the water furnished the consumers on many days during the past few years has not consistently conformed to the Treasury Standards so far as B. coli and turbidity are concerned. In April and May of 1933 the turbidity and bacteria count of the water was so high that the Commissioner of Health deemed it necessary to advise the people to boil all water used for drinking and culinary purposes. During this period many people resorted to the use of spring water carried from the several springs in the community.

## SEDIMENT IN MAINS AND TANKS

In considering turbidity it is of interest to note that at times the turbidity of the water furnished some consumers is less than that determined from the pumping station samples, while under certain conditions the turbidity is so high that the water is unfit to use. This difference in turbidity depends upon the length and time of flow before it reaches the consumers, the rate of flow, upon whether or not the water has passed through the reservoir or storage tanks, and upon the use made of the distribution system by the street flushers and fire department.

Observations made in the distribution system show that over a period of years much sediment, sand and muck has been deposited in the mains. Layers of sediment varying in thickness up to five inches have been observed. The elevated storage tanks were found to contain, after one season's use, layers as thick as 6 inches. The reservoir was found to contain, after 17 years use, a layer varying from 6 to 12 inches. Observations also show that the heavier particles of sediment are deposited in the mains near the pumping stations and the finer particles at the outskirts of the distribution system.

These conditions readily explain why at times a highly turbid water is furnished some consumers. With normal flow in the mains the sediment is but slightly disturbed and is not carried along. However, during times of increased flows the rush of water picks up the sediment and carries it to the consumers. This occurs when a main is closed and the water diverted to other mains; when the flow is reversed in the mains; and when the sprinklers, flushers or the fire department use the hydrants. The latter set up very high velocities and greatly disturb the sediment. Thus it can be seen that with a distribution system containing sediment, dirt and microscopic organisms, with or without odor, it is not always necessary to have an influx of turbid lake water to spoil one's appetite, an otherwise nice batch of laundry, or even spoil a refreshing bath.

## GELATINOUS PARTICLES IN WATER

Another objection to the quality of the treated water in Milwaukee, in comparison to the water obtained from water purification plants on the Great Lakes, is the presence of myriads of gelatinous particles which chlorination does not remove. Recent tests of Milwaukee's water supply made by John R. Baylis of Chicago, showed a sample

of tap water taken at the City Hall to contain 212,000 particles per 100 cc. with an average diameter of 10 microns\* or larger. Another sample taken at the pumping station contained 484,000 per 100 cc. A sample taken at the end of the breakwater in the lake showed 772,000 per 100 cc.; a sample from the mouth of the river, 740,000 per 100 cc. and a sample of the sewage disposal effluent showed 188,000 per 100 cc. A good many of the gelatinous particles ranged from 350 to 400 microns in diameter.

#### TASTES AND ODORS

Still another objection to the quality of the water are the undesirable tastes and odors which are periodically obtained. Lake Michigan water, like many other surface waters is subject to "grassy-fishy" tastes produced by living organisms and organic matter in the water. Such micro-organisms need only the presence of sunlight and carbon dioxide to grow abundantly, and Milwaukee experiences annually, the tastes and odors produced by these organisms, especially during the summer and fall months.

Probably the most objectionable taste in Milwaukee's drinking water is that caused by the combination of chlorine with phenolic industrial wastes thereby producing the so-called "iodoform" taste. While the discharge of industrial wastes directly into the rivers and lake has been largely controlled, nevertheless these wastes do enter the lake periodically and are carried to the water intake.

#### QUALITY OF WATER AND HEALTH

Since Milwaukee's water supply has not consistently conformed to accepted standards, it is of interest to determine what effect, if any, the quality of the water has had upon the health of the people. In general, it is true that some relationship exists between the quality of a water supply and the health of the community. This has often been illustrated both in this country and abroad where epidemics have occurred as a result of polluted water supplies. And yet, to what exact degree this relationship exists is difficult, if not impossible, to determine, because of the many factors that enter into the situation, and also because of the variation in the factors themselves.

In Milwaukee major improvements in the water supply have been followed by measurable reductions in the typhoid death rate. The

\* A "micron" or "micra" is 1/1000 of a millimeter. A bacteria is of 2 to 5 microns in length.

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application of calcium hypochlorite in 1910; the use of liquid chlorine in 1915; and the building of the Linnwood intake with the crib further from the source of pollution have been followed by reductions in the typhoid death rate (see figure 11). In this respect Milwaukee has enjoyed the experience of many other Great Lakes cities. The typhoid fever epidemic of 1916 which followed the shutting off of chlorination for several hours is another illustration, conversely, that

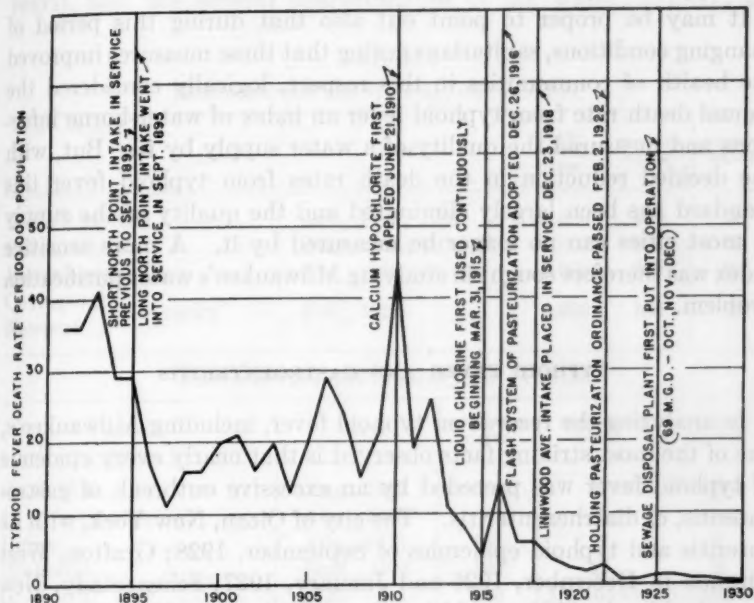


FIG. 11. TYPHOID FEVER DEATH RATE—1891 TO 1930, MILWAUKEE

(Calcium hypochlorite applied intermittently during the following periods: June 21, 1910 to December 12, 1910; none in 1911; February 2, 1912 to March 18, 1912; April 12, 1912 to March 31, 1915.)

in general there is some relationship between the quality of a water supply and health.

With reference to typhoid fever it may be proper to point out that most American cities including Milwaukee suffered with high death rates for many years. A relatively high death rate from typhoid fever appears to have been taken as a matter of course, and no special effort was made to remove its cause and eliminate it. When serious epidemics did take place and many lives were lost, public opinion

often became aroused, but unfortunately, the past was soon forgotten and in most instances no positive permanent steps were taken to prevent recurrences of such conditions. With the passing of time, however, and with the knowledge that water purification plants removed pathogenic organisms; that chlorine was effective in sterilizing water; and that sewage disposal works improved water supplies, conditions gradually changed so that today the annual death rate from typhoid fever in our larger cities is low.

It may be proper to point out also that during this period of changing conditions, sanitarians noting that these measures improved the health of communities in this respect, logically considered the annual death rate from typhoid fever an index of water-borne infections and measured the quality of a water supply by it. But, with the decided reduction in the death rates from typhoid fever this standard has been largely eliminated and the quality of the supply in most cities can no longer be measured by it. A more sensitive index was therefore sought in studying Milwaukee's water purification problem.

#### TYPHOID FEVER AND GASTROENTERITIS

In analyzing the records on typhoid fever, including Milwaukee's, one of the most striking facts observed is that nearly every epidemic of typhoid fever was preceded by an excessive outbreak of gastroenteritis, or diarrhaeenteritis. The city of Olean, New York, with its enteritis and typhoid epidemics of September, 1928; Grafton, West Virginia in December, 1926 and January, 1927; Schenectady, New York in March, 1920 and Milwaukee in February, 1916 are typical illustrations. Other illustrations are given in table 1.

It should not be inferred that every enteritis case is a potential typhoid fever case. Neither can it be inferred that enteritis is solely a water-borne infection because it occurs in cities with modern water purification plants. Then too, some children that do not drink water become infected. But, since extensive epidemics are associated with polluted water supplies it is logical to look with suspicion upon excessive numbers of gastro-enteritis cases and investigate the water supply. This was done in Milwaukee, with the gastro-enteritis mortality under two years taken as the index because it is a classification adopted by the U. S. Public Health Service and recorded in all large American cities.

## QUALITY OF WATER AND ENTERITIS

The gastro-enteritis death rate in Milwaukee is shown in figure 12 for the years 1879 to 1930. The major improvements in the water-works in 1910, 1915 and 1919 were followed by reductions in the death rate, and the lapses in the quality of the water supply in 1912 and 1916 were followed by an appreciable increase in the death rate.

The gastro-enteritis death rate per 100,000 population (under 2 years), and the several characteristics of the water, namely, the

TABLE 1  
*Gastroenteritis and typhoid fever in cities*

CITY	DATE	DIARRHEAL CASES	TYPHOID CASES	TYPHOID DEATHS
Santa Ana, Cal.....	Jan., Feb., 1924	10,000	369	28
Salem, Ohio.....	Aug., Jan., 1920-21	7,000	884	27
Bloomington, Ill.....	Jan., 1920	1,000	200	24
Covington } Kentucky.....	Feb., 1923	300	100	15
Newport }				

*Gastroenteritis and typhoid fever on ships*

VESSEL	DATE	ENTERITIS CASES	TYPHOID CASES	TYPHOID DEATHS
G. W. Hill.....	Aug., 1912	600	13	5
U. S. S. Gopher.....	Aug., 1913	85	3	
Huron.....	Aug., 1913	150	7	1
Rochester.....	Sept., 1913	122	42	5
G. W. Hill.....	1920	600	Unknown	Unknown
Capitol.....	1920	600	Unknown	Unknown
Pioneer.....	1920	18	5	
Lake Gaither.....	Nov., 1926	14	7	1

percent gas formers, the turbidity of the water, the *B. coli* index, and the 37° bacteria count, with the characteristics averaged monthly for a period of seven years, are shown in figure 13. When the water, on an average, was bad in spring and fall, the death rate was high. When the water was at its best in summer, the lowest death rate occurred.

The relation between the gastro-enteritis death rate and the water characteristics for the years 1928, 1929 and 1930 is shown in figure 14. A study of these curves shows that the trends of the curves are

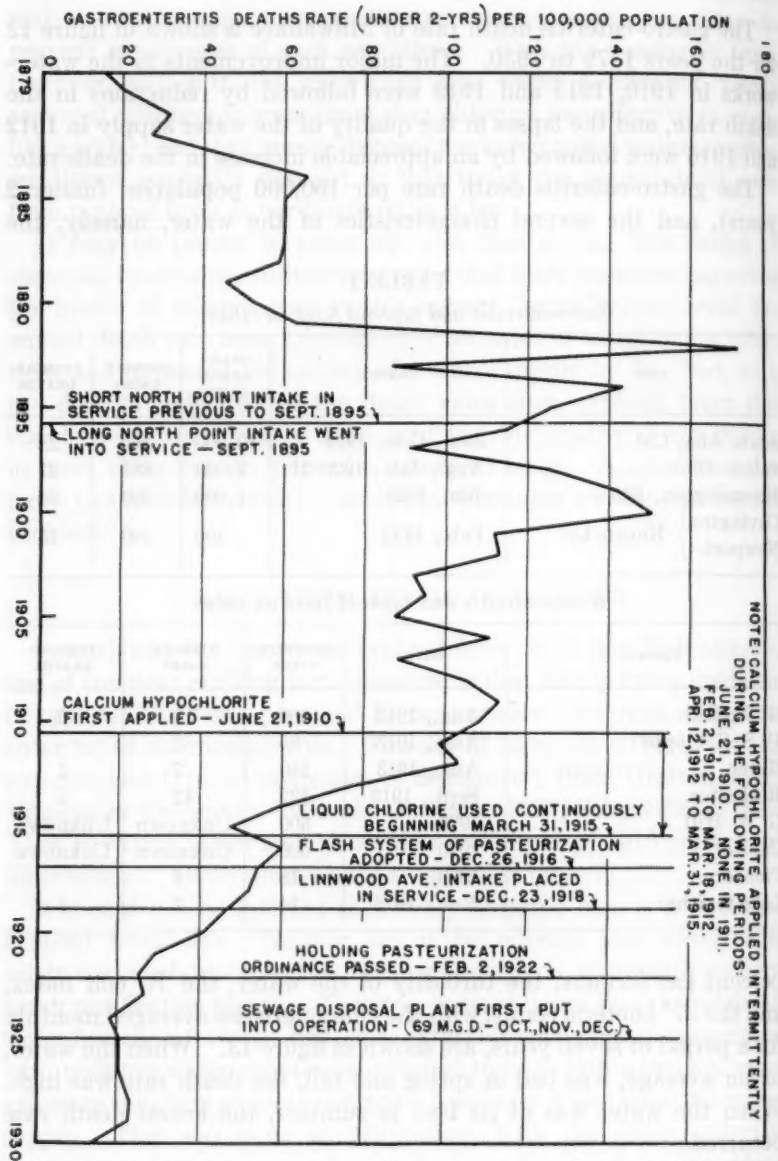


FIG. 12. GASTROENTERITIS DEATH RATE (UNDER 2 YEARS) 1879 TO 1930, MILWAUKEE

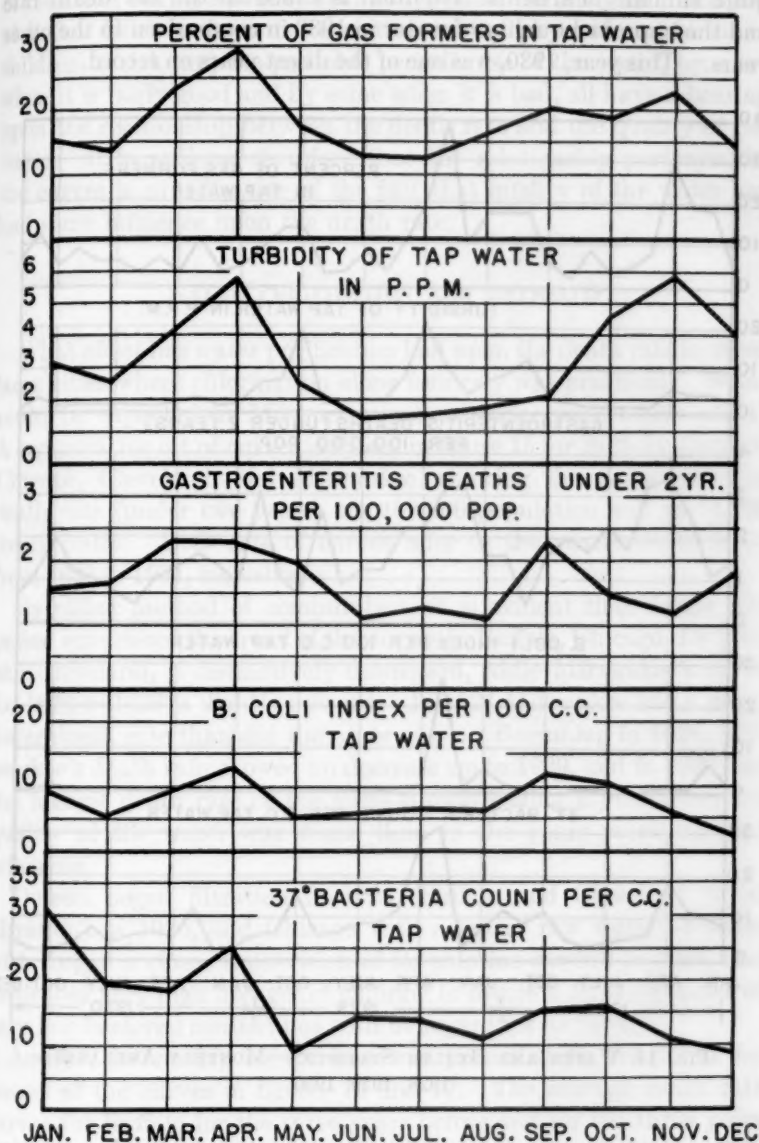


FIG. 13. SEVEN-YEAR AVERAGE OF MONTHLY AVERAGES 1924 TO 1930 INCLUSIVE, MILWAUKEE (Holding Pasteurization Ordinance passed February 2, 1922)

NOTE: CALCIUM HYPOCHLORITE APPLIED INTERMITTENTLY DURING THE YEAR

quite similar. Particular attention is called to the low death rate and the improved quality of water in 1930 in comparison to the other years. This year, 1930, was one of the driest years on record.

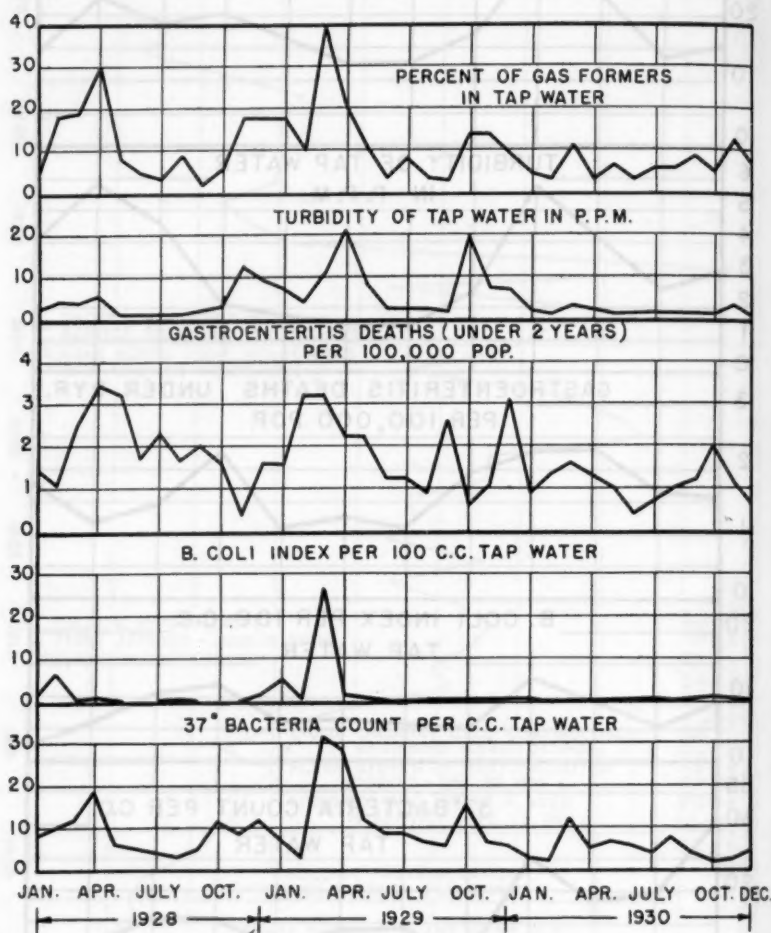


FIG. 14. WATER AND HEALTH STATISTICS—MONTHLY AVERAGES—1928, 1929, 1930

In considering the relationship between the deaths from gastroenteritis and the quality of the water, it must be borne in mind that a definite relationship between daily deaths and the quality of the water should not be expected to occur. The variation in the quality

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of the water during a twenty-four hour period, the analyses of samples of water twice a day, the variation in the physical resistance of children to sickness, the probable periodic use of the water, by some when it is fairly good and by some when it is bad, all have a bearing upon the relationship between the death rate and the quality of the water. It is striking therefore that the relationship portrayed in the curves is so indicative of the fact that quality of the water has had some influence upon the death rate.

#### WATER PURIFICATION AND ENTERITIS

What effect has water purification had upon the death rate in other large cities where chlorination alone formerly was practised? What could be expected in Milwaukee with a water purification plant? A comparative set of curves is shown in figure 15 for Buffalo, Detroit, Chicago, Cleveland, and Milwaukee, showing the gastro-enteritis death rate (under two years) per 100,000 population and per 1,000 living births. Both sets of curves refer to the yearly death rates from 1923 to 1931, inclusive.

By either method of computation, it is evident that during the period considered the trend of the curves in Buffalo, Chicago, Detroit, and Cleveland, is distinctively downward, while Milwaukee's curve for 1924 to 1929 is slightly upward. In 1924 Milwaukee had a much lower death rate than did the other cities. Beginning in 1926, Milwaukee's death rate showed no decrease up to 1929, and in 1929 had the highest death rate of the cities shown, during a year when the quality of the water was worse than in the years preceding and following.

Detroit began filtration in 1924, Buffalo and Cleveland (total filtration) in 1926, and Chicago with a better raw water to begin with, began a closer supervision of its chlorine control in 1924, and instituted very high dosages of chlorine to insure a drinking water of very low bacterial content but with no regard for its taste.

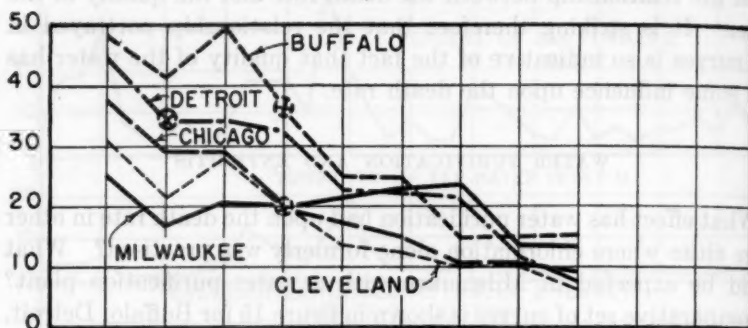
Another interesting comparison was presented to the public by means of the curves in figures 16 and 17. The average death rate curves for Buffalo for the three years before and for the three years after the purification plant went into operation are shown in figure 16. The average death rate curves for Milwaukee for the same years are shown in figure 17. While Buffalo experienced a reduction in each month of the year for the periods considered,<sup>1</sup> Milwaukee had a higher

DEC.

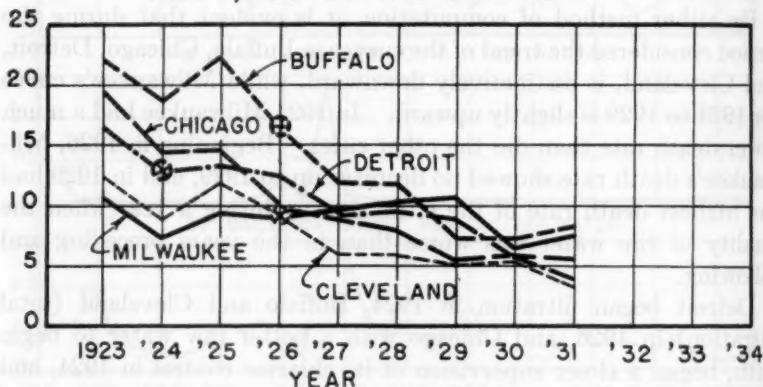
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death rate in several months of the latter three year period. Similar studies for other cities showed a similar condition.

### GASTROENTERITIS DEATH RATE UNDER 2YRS. PER 100,000 POPULATION



### GASTROENTERITIS DEATH RATE UNDER 2-YRS. PER 1,000 LIVING BIRTHS



⊗ DENOTES YEAR IN WHICH FILTRATION BEGAN  
NOTE: CLEVELAND FILTERED 50 PERCENT OF  
ITS WATER PREVIOUS TO 1926. IN 1926 IT  
BEGAN FILTRATION OF ENTIRE SUPPLY.

FIG. 15

It appears reasonable to believe, therefore, that there is a relationship between the quality of the water and the death rates due to gastro-enteritis (under two years) in Milwaukee, and that the mortal-

Similarity among young children has been somewhat higher than would be expected if the city had been provided with an absolutely uncontaminated water supply.

- · — 6 YR. AVER. OF MONTHLY RATES 1923 TO 1929 INCLUSIVE - 1926 NOT INCLUDED
- - - 3 YR. AVER. OF MONTHLY RATES BEFORE PURIFICATION 1923 TO 1925 INCL.
- 3 YR. AVER. OF MONTHLY RATES AFTER PURIFICATION 1927 TO 1929 INCL.

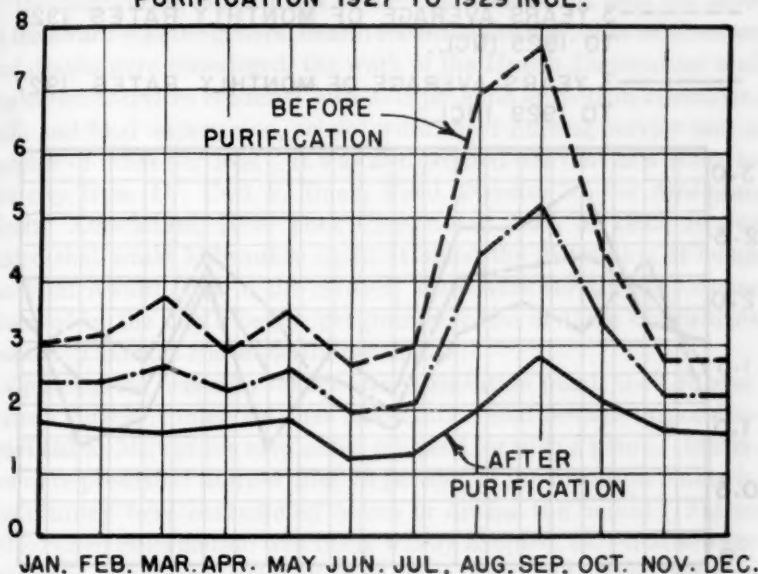


FIG. 16. BUFFALO, N. Y., GASTROENTERITIS DEATH RATE (UNDER 2 YEARS) PER 100,000 POPULATION (Purification plant went into operation in 1926)

#### OBJECTIONS TO WATER PURIFICATION PLANT

Notwithstanding all these data the building of a water purification plant was opposed, primarily by those citizens who are more concerned with their financial interest in the matter than with the health, comfort and convenience of the community. Following the investigation and recommendation by J. W. Ellms in 1921, a group of local chemists, headed by John A. Wilson, recommended delay because at

that time developments in colloidal chemistry led them to believe that revolutionary discoveries which would increase filter rates and consequently reduce plant size and cost, were imminent. Despite two independent investigations in the same year immediately following the chemists report, one by the U. S. Public Health Service and the other by Harrison P. Eddy, both recommending immediate construction of a plant, the project was sidetracked.

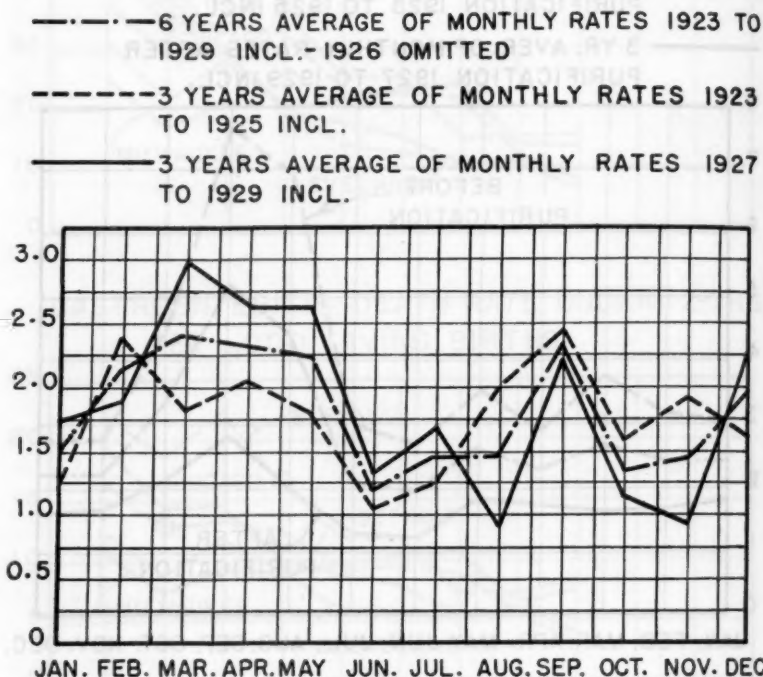


FIG. 17. MILWAUKEE, WISCONSIN. GASTROENTERITIS DEATH RATE (UNDER 2 YEARS) PER 100,000 POPULATION

The Engineering News-Record in its issue of July 7th, 1921, commented editorially upon the action of the Chemists Society in holding up needed public works pending possible discovery of future scientific improvements. The editorial portrayed the Milwaukee chemists as men without experience in water treatment lightly leaping into the subject and disregarding the opinions of experienced sanitary engineers. The editorial closed with the statement that "in their

haste or zeal to promote chemical service, the Milwaukee chemists seem to have over reached."

From time to time the Citizens' Bureau of Milwaukee issued bulletins in opposition to the water purification plant. This Bureau contended that it was not plausible that the water supply was in any way questionable from a health standpoint because Milwaukee won first place among cities of over 300,000 population in the Inter-city Health Competition, sponsored by the United States Chamber of Commerce and the United States Public Health Association, in 1929 and in 1931, and second place in 1930.

The engineering department of the city pointed out that the basis of the award was the general health record of the city, that all diseases and deaths were considered, the work of the Health Department and the various services rendered such as diphtheria anti-toxin injections, milk and food supervision, school work, field nursing service and a number of other services. It was also pointed out that in a letter to the city from Dr. Carl F. Buck, Field Director of the American Health Association, New York City, dated Nov. 8, 1932, it was stated that while Milwaukee again attained the distinction of being the First Award City in the contest, there were certain deficiencies observed in the city's health program and one of these deficiencies was the "Diarrhea and Enteritis death rate."

Opposing the necessity for a water purification plant, the Citizens' Bureau further contended that chlorination and sewage disposal as practiced at Milwaukee eliminated the need for such a plant. Statistics were presented to show that 75 percent of the filtration plants in this country were constructed before or during the period (1911 to 1915), when chlorination was being widely adopted, and that sewage treatment plants only attempted to effect 30 to 50 percent purification. With Milwaukee's sewage treatment effecting a 90 to 95 percent efficiency, an elaborate water purification system was unnecessary.

However, the investigation by the engineering department disclosed that of all the plants on the Great Lakes, only those at South Milwaukee, Wis., and Evanston, Ill., were built prior to 1915 while the plants at Sheboygan, Racine and Kenosha, Wis.; Highland Park, Lake Forest, Glencoe and Winnetka, Ill.; East Chicago, Indiana; St. Joseph, South Haven and Detroit, Mich.; Cleveland, Ohio; Buffalo, N. Y.; Toronto and Windsor, Canada, were all built subsequent to the period 1911 to 1915. Milwaukee, being a Great Lakes city must be

classified accordingly and cannot be considered with those communities whose highly polluted and turbid water supplies necessitated filtration of their water to protect their very existence and growth. We considered the fact that approximately 90 percent of the filtration capacity on the Great Lakes, built since 1911 to 1915, subsequent to the development of efficient chlorination, a recognition of the one-line defense presented by chlorination and the necessity for something better.

The Citizens' Bureau further contended that filtration did not remove tastes in water caused by the combination of phenol and chlorine. The Bureau also presented statistics based on annual averages to show that since 1927 Milwaukee's water was far superior to the requirements of the U. S. Treasury standards. And yet during this period, there were numerous occurrences of highly polluted, turbid and ill-tasting water which at times necessitated a warning from the Commissioner of Health to boil all water used for drinking purposes.

Opposition to the plant did not cease after it was unanimously approved by the city's Common Council, but was carried before the Public Service Commission of Wisconsin, the courts and finally the Public Works Administration in Washington.

When the City applied to the Public Service Commission for a certificate of convenience and necessity to construct a water purification plant, John A. Wilson appeared in opposition to the plant. In this instance Mr. Wilson contended that a purification plant was unnecessary and because of the average clarity of Milwaukee's water, such a plant might even prove harmful. The hazard occurs, according to Mr. Wilson, because groups of bacteria become coated with a film of colloidal alumina in which state they pass through the filters and are protected to a very large extent against destruction by chlorination. Despite the opposition the permit was granted by the Commission, but court action was begun in the name of a laundry company to set aside the Commission's order. Before the court, Mr. Wilson repeated and elaborated upon his testimony before the Public Service Commission, but at no time offered evidence that his theories on the protection of bacteria by coatings of alumina were borne out in any purification plant operating on the Great Lakes or elsewhere.

Mr. John R. Baylis, Chicago, Ill., physical chemist, offered in direct contradiction, concrete evidence that a water purification

plant removed all of the alumina added to the water and that ten years of experimentation upon the subject has failed to produce any evidence of the protective coating of alumina on the bacteria as stated by Mr. Wilson. The court decision upheld the order of the Public Service Commission and commented on the preponderance of evidence favoring the construction of a water purification plant.

The opposition carried to Washington an attempt to prevent the issuance of a loan and grant by the Public Works administration to the City, but to no avail. These are but a few of many objections presented to the public and officials in order to obstruct the building of the plant and offer an indication of the strength and ingenuity of the opposition with which the engineering department had to contend.

#### EDUCATIONAL CAMPAIGN

To show the fallacy of the many objections and particularly to convince the public that a plant is necessary to safeguard and improve the quality of the water supply, a campaign of education was carried on by the engineering department. Over a period of several months many illustrated discussions were made before Business Advancement Associations, Parent-Teachers Associations, Church Clubs, Clubs of the Tax Payers Association, Service Clubs and Engineering Societies. From time to time a new phase of the problem was set forth in order to give the press an opportunity to bring something new to the public. Samples of turbid waters were placed before the public in order to fully acquaint the people with the conditions in all parts of the city.

The engineering department presented information to the public relative to the quality of the water furnished in neighboring cities with purification plants and samples of water before and after purification were exhibited. Illustrations showing the efficiencies of neighboring water purification plants in removing bacillus coli, bacteria, and turbidities were also presented to the public and comparisons made with conditions in Milwaukee.

As a result of this educational campaign the public became well acquainted with the whole problem and when it finally was brought before the city's governing body it met with their support and the construction of a plant was unanimously approved.

#### LOCATION AND DESCRIPTION OF PLANT

The water purification plant under construction will be located upon the shore of Lake Michigan near the north end of Lake Park

at the north end of the city, and will occupy the present beach and filled ground enclosed and protected by a breakwater. The general design of the visible structures will be in keeping with the adjacent park and the high class residential district in the vicinity.

The plant will take water from the existing Linnwood Avenue (12 foot) tunnel, purify the water, store it in suitable clear water basins and return it to the Linnwood Avenue tunnel (see figure 18). The

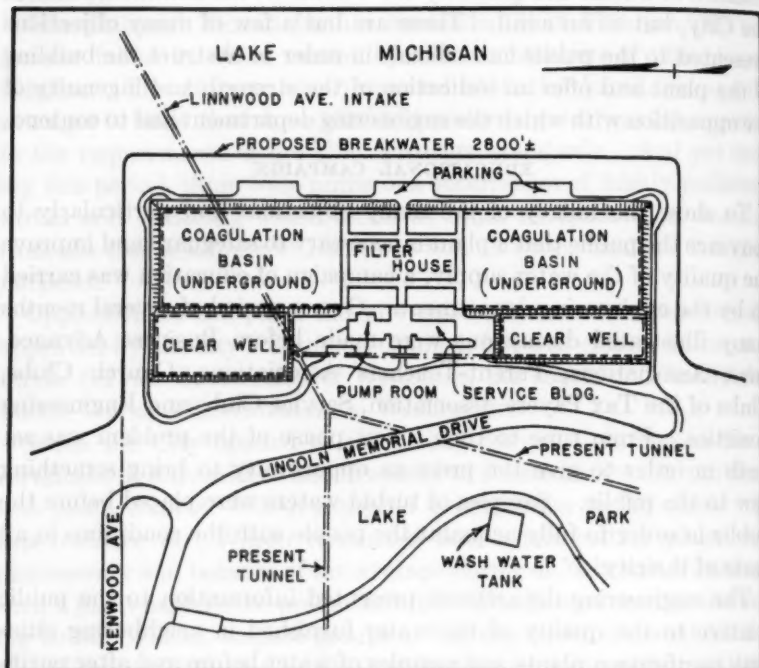


FIG. 18. WATER PURIFICATION PLANT FOR THE CITY OF MILWAUKEE  
(Preliminary plans)

water will then pass to the existing tunnel system at the present North Point Pumping Station and the Riverside Pumping Station which supply the entire city and certain environs thereof. The plant will be of the mechanical gravity type, equipped with facilities for electric pumping, activated carbon and chlorine, flocculation equipment, coagulation basins, filters and clear water storage reservoirs, together with the necessary appurtenances that will make these processes effective. The plant will be equipped with a head house structure

which will accommodate the chemical feeding equipment and house a laboratory, lavatory and locker room facilities and the administrative offices of the plant.

The capacities of the principal parts of the plant will be as follows:

Rated capacity of plant.....	200 m.g.d.
Low lift pumping plant, five 50 m.g.d. units.....	250 m.g.d.
Mixing or flocculation basins, retention period at rated capacity of plant.....	30 minutes
Coagulation basins, retention period at rated capacity..	4½ hours
32 filter units, rated capacity each at 2 gallons per sq. ft. per minute.....	6½ m.g.d.
Clear water reservoir capacity.....	30 m.g.d.

In the operation of the plant, the raw water will be pumped from the Linnwood Avenue tunnel and delivered to the head house where the chemicals will be introduced. Facilities will also be provided for feeding chemicals elsewhere at appropriate places. The water will then pass through flocculation or mixing basins where it will be gently stirred by mechanical equipment. Thence it will pass through the coagulating basins to and through the filters and will be stored in three reservoirs.

The supply or site will be protected by a breakwater of the steel sheet piling and rock fill type. Proposals for the breakwater have been received and a contract will soon be awarded.

The lake bed on the site of the work consists of a thin layer of sand and gravel, more or less interspersed with boulders lying on a glacial deposit of brown clay, and, the coagulating basins and the isolated clear water reservoirs will be supported upon water consolidated sand deposited by hydraulic dredging operations.

#### *Low lift pumping equipment*

The low lift pumping equipment will consist of five 50 million gallon horizontal direct connected electrically driven centrifugal pumps, designed for 50 feet head. Pumps will take water in pairs from the suction tunnel riser shafts and will discharge into suitable pipes or conduits leading through the head house.

The pumps will be controlled by mechanically operated valves.

#### *Conduits*

Conduits to carry the water through the plant will be built of reinforced concrete or steel for certain conduits, and will be controlled

by suitable mechanically operated sluice gates and valves so as to effectively isolate each part of the conduit system, basin system and filter system when necessary for inspection, cleaning and repairs.

#### *Mixing and coagulating*

The mixing and coagulating basins will be constructed of reinforced concrete with reinforced concrete column and slab covers supporting earth filling and sod.

Following special mixing devices in the head house to disseminate chemicals thoroughly through the water, the water will pass to the so-called flocculation or mixing basins which will be an integral part of the coagulation basins in the first passage thereof. Here the water will be flocculated by gentle stirring and thence pass through the coagulation basins to the filters.

These basins will be divided into four separate treatment units, any of which can be isolated when required.

#### *Filters*

Each filter will have a filtering sand surface based upon a filtration rate of two gallons per square foot per minute. Filter beds will be constructed of reinforced concrete.

The filters will be of the mechanical gravity type built on the central gutter system with 30 inches of filtering sand and 24 inches of gravel. Wash troughs and gutter system will be provided to accommodate the wash rate equivalent to 2 feet rise under winter conditions and 3 feet under summer conditions.

All water passages immediately adjacent to the filters will be accommodated in a suitable pipe gallery in which will be installed hydraulic valves and controllers for accurately governing the rates of filtration and the operation of washing. The larger conduits will be constructed of reinforced concrete. Wash water sewers will be so built that any leakage therefrom can be detected before it could enter the clear well.

#### *Clear water reservoirs*

The clear water reservoirs will be constructed of reinforced concrete divided into three compartments. One compartment will underlie the filters. The two remaining compartments will be constructed utilizing column and flat slab roofs supporting earth filling and sod.

Each reservoir compartment will be connected to the outlet clear water tunnel by suitable mechanically operated sluice gates.

### *Superstructure*

All superstructures will be built of brick masonry or stone except where reinforced concrete is practicable and will be trimmed or faced with stone. All construction will be fireproof and so designed architecturally inside and outside as to be proper for a structure located in and adjacent to a park.

The superstructure will include housing for pumps, headhouse, filters, chemical storage, general service building and shop.

### *Wash water*

Wash water will be provided by two electrically driven centrifugal pumps having a capacity of 20 m.g.d. each, taking water from the filtered water reservoir system, and discharging the same into the wash water system.

The water system will be connected to a storage reservoir containing 750,000 gallons, located underground in the park at a suitable elevation to provide sufficient head for washing filters. The reservoir will be constructed of reinforced concrete with column and flat slab roof covered with earth filling and sod.

The wash water reservoir is now under construction.

### **FUTURE ADDITIONS**

In the planning of the supply, provisions have been made for additions to the plant as required in the future and each principal part of the plant will be constructed in units to readily facilitate enlargement. Wherever pipes or conduits or openings for the passage of water cannot be conveniently enlarged, liberal provisions for future increase will be made in the design.

### **COST**

The estimated cost of the work including preliminary expense, breakwater, filling-in, construction, engineering and overhead, and interest during construction, is approximately \$4,600,000.

The annual operating cost is estimated at \$4.75 per million gallons treated, based upon treating 31,000 m.g. per year or 85 m.g. per day.

## COST OF WATER PURIFICATION

In view of the fact that many citizens were interested in the cost of purification, to the extent that it would become a part of the bill for water, a careful analysis of costs, including the interest on the investment, depreciation, operation and maintenance of the plant, for each class of consumers depending on the quantity of water used, was made. This is shown in table 2.

Using the 1929-30 water department accounts as a basis, the number of accounts in each quantity group was estimated for the year 1940, and under the normal rate of 7 cents per 100 cubic feet (city has now an emergency rate of 6 cents) and the estimated pumpage for 1940 the cost of purification to each group was estimated.

Table 2 shows that the cost of purification amounts to about 10 to 12 percent of the annual bill for water. For 70 percent of the accounts the average cost would be about 5 cents a month and for 22 percent about 13 cents a month. For 92 percent of the accounts the average cost would be about 7 cents per month.

## UNEMPLOYMENT RELIEF

While the building of a water purification plant need not be justified from an unemployment relief standpoint, the fact remains that the building of the plant will aid in the relief of the unemployed. Estimates show that approximately 1,900,000 man-hours of direct labor will be employed in the field. This is equivalent to 40 weeks of work at 30 hours a week for 1,580 men. Estimates also show that approximately 230,000 tons of material will be used in the building of the plant.

## FINANCING OF PROJECT

The project will be financed through an issue of water revenue bonds, and a contract has already been entered into between the City and the Federal Administrator of Public Works under the terms of the National Industrial Recovery Act. Under that contract the City is to receive, as an outright grant, a sum equal to 30 percent of the labor and material used on the project; and will borrow the remainder. Some or all of the bonds may be sold directly to the public instead of to the government as a result of the widespread demand for the bonds during the past few months.

TABLE 2

Classifications of consumers and costs, also, costs of purification based on \$0.07 rate, 1 percent depreciation, 5 percent interest rate, \$5.00 per m.g. cost of operation

Estimate for 1942—Pumpage 34,500,000,000 gallons; plant cost \$4,500,000.00

AMOUNT PAID PER YEAR	NUMBER OF ACCOUNTS	PERCENT OF ACCOUNTS	APPROXIMATE CONSUMPTION	COST OF PURIFICATION ON CONSUMPTION	AVERAGE COST	PERCENT OF ACCOUNTS
			cu. ft. per year			
Less than 2.00	813	0.79				
2.00— 3.00	2,250	2.18	700	0.07		
3.00— 4.00	5,170	5.02	2,200	0.21		
4.00— 5.00	9,050	8.79	3,600	0.34	0.60	70.41
5.00— 6.00	12,900	12.52	5,000	0.47		
6.00— 7.00	12,600	12.22	6,400	0.60		
7.00— 8.00	11,650	11.30	7,900	0.75		
8.00— 9.00	9,580	9.30	9,300	0.88		
9.00— 10.00	8,540	8.30	10,700	1.01		
10.00— 15.00	18,280	17.77	15,000	1.42		
15.00— 20.00	4,830	4.69	22,200	2.10	1.56	22.46
20.00— 25.00	1,770	1.72	29,300	2.77		
25.00— 30.00	1,010	0.98	36,400	3.44		
30.00— 35.00	618	0.60	43,600	4.12	3.70	4.27
35.00— 40.00	423	0.41	50,700	4.79		
40.00— 45.00	340	0.33	57,900	5.47		
45.00— 50.00	237	0.23	65,000	6.14		
50.00— 60.00	412	0.40	75,700	7.15		
60.00— 70.00	319	0.31	90,000	8.50		
70.00— 80.00	195	0.19	104,300	9.86		
80.00— 90.00	185	0.18	118,600	11.21		
90.00— 100.00	134	0.13	132,900	12.56	19.10	2.36
100.00— 200.00	670	0.65	211,400	19.98		
200.00— 300.00	278	0.27	354,300	33.48		
300.00— 400.00	144	0.14	497,100	46.98		
400.00— 500.00	93	0.09	640,000	60.48		
500.00— 600.00	62	0.06	782,900	73.98		
600.00— 700.00	62	0.06	925,700	87.48		
700.00— 800.00	41	0.04	1,068,600	109.98		
800.00— 900.00	41	0.04	1,211,400	114.48		
900.00— 1,000.00	21	0.02	1,354,300	127.98	191.10	0.45
1,000.00— 2,000.00	154	0.15	2,140,000	202.23		
2,000.00— 3,000.00	55	0.05	3,568,600	337.23		
3,000.00— 4,000.00	21	0.02	4,997,100	472.23		
4,000.00— 5,000.00	14	0.014	6,425,700	607.23		
5,000.00— 10,000.00	30	0.029	10,711,400	1,012.23		
Over 10,000.00	17	0.017	49,997,100	4,724.73	2,355.05	0.05
Total.....	103,000					

## DESIGN AND CONSTRUCTION

The firm of Alvord, Burdick and Howson, Chicago, Illinois, has been engaged in a consulting capacity. The detailed design, and preparation of plans and specifications is being carried out by city forces. The wash water tank is under construction and proposals have been received for the breakwater or revetment wall to enclose the fill.

## CONCLUSIONS

The water purification problem in Milwaukee may be summarized as follows:

(1) Since 1911 the City has received eight reports from private and governmental sanitary engineers recommending the building of a water purification plant, the last two having been received in 1931.

(2) Sewage and industrial wastes will always be periodically discharged from the combined storm and sanitary sewer system and at the sewage disposal plant. This pollution together with the effluent from the sewage disposal plant will cause bacterial contamination of the waters in the bay.

(3) The quality of the intake water is to some extent dependent upon rainfall, prevalence and intensity of storms, and winds that carry the pollution to the intake.

(4) The present treatment with chlorine cannot be adjusted according to the degree and variability of the pollution of the raw water, and does not consistently produce a water that conforms to accepted standards of physical and bacterial quality.

(5) A relationship appears to exist between the quality of the water and the health of the community, as evidenced by the relationship between the quality of the water and the death rate from gastroenteritis (under two years).

(6) The building of a plant has been opposed, but the arguments raised in opposition thereto have been illogical, prejudiced and based on financial self interest.

(7) The educational campaign placing before the people the merits of a water purification plant aided in the solution of the problem.

(8) The 200 M.G.D. plant under construction is estimated to cost \$4,600,000 and the cost of operation \$4.75 per million gallons treated, based upon treating 31,000 m.g. per year or 85 m.g. per day.

(9) The cost of purification as a part of an annual bill for water is

equal to about 10 to 12 percent of the bill, and for 92 percent of the accounts is equal to about 7 cents per month.

(10) The project will provide about 1,900,000 man-hours of work in the field and about 230,000 tons of material will be used.

(11) The project is being financed under a contract with the Federal Emergency Administrator of Public Works under the terms of the National Industrial Recovery Act with an outright grant of 30 percent of the cost of labor and materials. Water revenue bonds will be sold to the government and the public.

### DISCUSSION

JOHN R. BAYLIS (*Chicago, Ill.*): Milwaukee's 25-year fight for a purer water supply is about to be realized. It serves as a good illustration of the difficulties encountered in attempting to purify water which, while considerably below the present quality of most public supplies, is not very highly polluted. It would not now be difficult to put through a program of purifying a grossly polluted water in almost any city, for public sentiment would demand that something be done, but it is not so easy when the water is fairly pure most of the time. There probably is not close agreement even among sanitary engineers and chemists as to how pure water should be before improvement is deemed advisable.

If the consumer had his choice of various qualities of water at different prices so that he might select almost any kind somewhat as he does food, clothing, or automobiles, it would be possible to get some information on how much one is willing to pay for a high quality of drinking water. I am of the opinion that the quality selected by the vast majority would be so much above that being supplied by many public supplies that we would be amazed at what the public is willing to spend for water of superior quality. Unfortunately there is no way this can be demonstrated as it can be with automobiles or other things which add to our comfort and convenience.

With the vast amount of data gathered by Mr. Schwada on the need of improving Milwaukee's water, there can be no question about it being a much needed improvement, and an improvement which the vast majority of Milwaukee citizens will appreciate. Every water engineer and chemist, I am sure, admires the remarkable fight which has been made by Mr. Schwada to construct a filtration plant for Milwaukee. One obstacle after another has been thrown in his

way by a small minority of citizens, and while all opposition has been overruled, it has greatly delayed construction of the plant.

There is no reason why filter plants should not have been constructed in Milwaukee following reports of consulting engineers prior to 1920, or at least the Ellms' report of 1921. Under the leadership of one of Milwaukee's chemists, construction of the plant was postponed in 1921. This will stand as a disgrace to the chemical profession for years to come, because the reasons set forth by the chemists were not based upon sound chemical facts. I do not think this chemist knew how to interpret experimental work on water treatment.

Mr. Schwada's experiences at Milwaukee are going to be largely the same for Chicago and New York before filtration plants are constructed. That the people want an improved water in the cities mentioned, there can be no question, but the protests of a few who have selfish motives usually is sufficient to delay greatly any effort towards improving water which is not very highly polluted. Water works officials must resort to unusual means to convince the public that an improvement in the quality of the water can be made by filtration. Chicago may be slightly more fortunate than Milwaukee in convincing the public, due to the Experimental Plant. Water is given to those who care to go to the plant for it. There is no question in my mind that the sentiment in Chicago is overwhelmingly in favor of filtration, yet the date for starting construction on the first filtration plant cannot as yet be set. The Experimental Plant has served to combat opposition similar to some of that which has developed in Milwaukee, and probably would have developed in Chicago had the plant not been available. The city officials in advocating filtration do not have to try to convince the public that filtered water is better than the present chlorinated lake water. All that is necessary is to invite the person who might be doubtful to try the filtered water at the Experimental Plant. So popular has this water become that when notice was posted some time ago that dispensing filtered water would be discontinued, there were so many protests it was decided to keep the plant in operation. It seems probable that it will have to be kept in operation until the larger plant is constructed.

Water works officials in cities where the water is not highly polluted, and yet is not up to our present day standard, must resort to means not considered necessary heretofore to convince the public of the value of a high grade of water. They must start their programs for

filtration perhaps several years in advance to successfully combat minority opposition which is sure to develop.

Mr. Schwada's remarkable fight at Milwaukee should serve as an inspiration to others in a similar position. Many in his position would have become discouraged and stopped making efforts to carry the program through, but Mr. Schwada is not this type. If he ever became discouraged I think it made him fight that much harder. Certainly he should be highly commended by our profession for the unusual efforts he has made to get purer water for Milwaukee. The paper speaks for itself. It is the results of careful study and securing information essential for carrying through the program. Without this complete and convincing evidence of the need of purer water, Milwaukee might not now be starting on actual construction of the plant.

## AUTOMATIC PUMPING EQUIPMENT AND THE TELEPHONIC SUPERVISORY SYSTEM IN BALTIMORE

By LEON SMALL

*(Water Engineer, Baltimore, Md.)*

During an extended experience in the design, construction and operation of the various features generally used in the water works field, I have always been strongly inclined toward the view that whenever a routine operation must be performed, such an operation can be executed automatically to much better effect than manually, particularly where the exercise of individual judgment may have an unfavorable effect on the results obtained from such operation. I have especially considered this true in the rather specialized branch of water works engineering which the design of pumping stations involves. When we consider the magnitude of the forces at play in the operation of a pumping station, even of moderate size, and the relative ease with which serious damage to the pumping equipment and the connected distribution system may sometimes result from faulty manual operation, an appreciation is had of the merits of automatic operation, particularly for certain functions, with its qualities of predetermined timing and sequence of unvarying regularity if the apparatus is in proper working order, and its honesty in not trying to conceal the facts if it is not. An example of this is found in the operation of discharge valves on centrifugal pumps. With manual control, pressure disturbances on the distribution system incident to opening and closing the valve are of varying quantities, dependent largely on the skill and care of the operator and they may, and frequently do, reach values that are damaging to the system; perhaps not immediately apparent, but very likely to have an undesirable cumulative effect. With the rate of opening or closing a pump discharge valve controlled automatically, predetermined and set at the time of installation and test, the disturbances on the system resulting from the use of the valve can be limited to the minimum; and the responsibility of the operator confined at most to initiating the operation of the valve in the desired direction.

The increasing use of electric power in pump drives, more noticeable in recent years, has vastly increased the possibilities for automatic control in pumping stations; and the use of electricity, either alone or as an adjunct to mechanical devices, has placed at our command efficient means of accomplishing results heretofore not considered practicable.

We have to a large extent taken advantage of the possibilities offered by the application of automatic control devices to the operation of pumping stations in Baltimore, and our newer stations, even in large sizes, have been so designed that manual attendance has been reduced to the minimum. Where such attendance is used, the exercise of judgment on the part of the attendant in the operation of the equipment is negligible. A little more than three years ago we abandoned our last steam-driven station; and with complete electrification of our pumping plants we have had at our disposal the advantages of automatic control schemes made possible by electricity. Although some of our control methods function entirely through mechanical means, and others are to a great extent mechanical with electricity playing but a supplementary part, as will be noted from the description of some of our automatic schemes which follows, for the most part our automatic pumping equipment is fully electric in its functions.

#### BALTIMORE PUMPING STATIONS

In Baltimore our automatic pumping equipment is found in stations of three general classes. The first classification includes a plant such as our Vernon Station, in which the starting and stopping of the equipment is initiated manually, with the services of the operator limited to pulling two pull-buttons of the electrical system to start, and turning the handle of one hydraulic control valve to stop; all succeeding functions of the equipment in either case being entirely automatic and in accordance with an established schedule of timing to accomplish the desired results with the minimum of disturbance on the incoming power lines and the water distribution system. The second group of our classification is typified by our Guilford Station, now in service, and our Ashburton Station, now under construction. These stations are entirely automatic in operation, and although attended, the services of the attendants are but supervisory in character. Their active part in the operation of the equipment arises only on those infrequent occasions when the nor-

mally automatic scheme of control is turned over to a manual-automatic system, one similar to the Vernon type first mentioned, when such an operating method is desirable because of work being done on the distribution system, or for some similar cause. The third and final classification of our group of automatically operated stations includes those at Catonsville, Pikesville and Towson, these being suburbs of Baltimore served by our water system. The stations in this category are entirely unattended, except for casual inspections by our maintenance men and a routine visit weekly for the purpose of changing charts. The Catonsville Station was placed in service in 1928 and, although its record has been entirely satisfactory, it does not represent the possibilities of completeness of automatic control shown by the other two stations in the group. The Towson and Pikesville Stations are practically identical, except for the pump units, and they each include the telephonic supervisory system which we will describe and, it is hoped, demonstrate later.

In a consideration of the automatic pumping equipment in Baltimore, particularly of those stations completely automatic in action, it should be noted that all of our stations pump to either reservoirs or standpipes, of ample capacity, with the supply fed therefrom when pumping is discontinued. No direct pumping is done, except on special occasions; under such circumstances the operation of the affected station is controlled manually. Mention is made of this fact to avoid any misunderstanding as to the applicability of the control schemes in Baltimore to places where the reservoir system is not used.

#### *Examples of automatic control*

A description of certain features of automatic control used in stations of the several types mentioned, with the aid of figures, may be of interest. One of the pump discharge valves in our Vernon Station is shown in figure 1. This shows, in the open position, a standard Cone valve to which we have added a check valve, with a by-pass, in the exhaust connection from the operating cylinder on the opening stroke, and an auxiliary cylinder and piston, with connections to a control table, mounted above the main pilot valve mechanism. Normally, the valve on the control table is set so that the auxiliary piston is raised to the clear position, thus having no part in the functioning of the pilot valve. The pump is started with the discharge valve closed and, when the pressure on the inlet pitot con-

nection is adequate, the diaphragm raises the pilot valve, admitting power water to the operating cylinder in the opening direction. The exhaust water from this cylinder is blocked by the check valve and the water is forced to take to the by-pass; the latter being provided with a regulating valve that has been set and locked at the point where the rate of opening is that which we desire.

Figure 2 shows how a normal closure of the valve is effected. With the pump running, the pilot diaphragm and pilot valve are

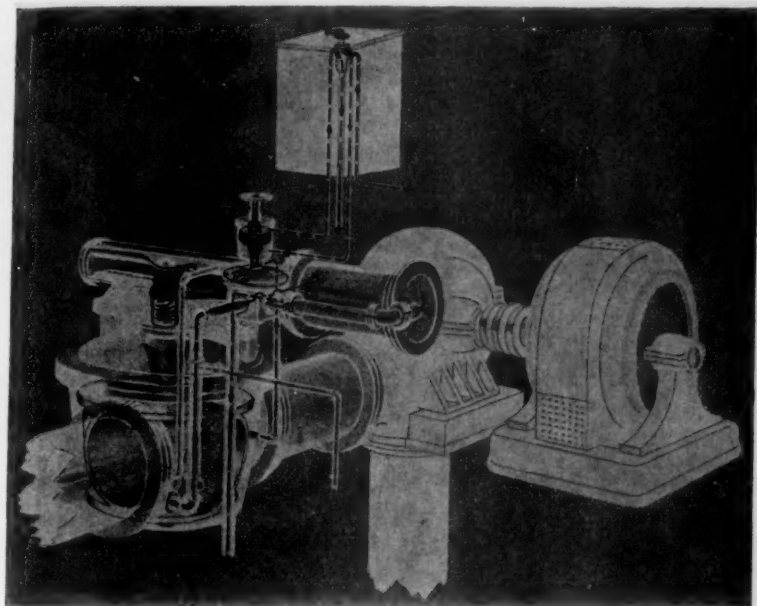


FIG. 1

maintained in the raised position, holding pressure on the operating cylinder in the open direction, and the auxiliary piston is raised. Manipulation of the valve on the control table places downward pressure on the auxiliary piston, this forcing the pilot diaphragm and pilot valve in the closing position, despite the differential pressure of the pitot connections tending to hold them up. The downward movement of the auxiliary piston is limited by a distance piece in the bottom of its cylinder, the distance piece being so dimensioned that the full stroke of the auxiliary piston is just sufficient to push

the pilot valve slightly in the closing position, admitting power water slowly to the operating cylinder on the closing stroke. The final movement of the operating cross-head trips a limit switch, not shown, on the end of the cross-head frame, acting to shut down the pump motor.

Figure 3 shows how the Cone valve control functions in an emergency, such as a loss of power to the station or a sudden shut-down initiated by other causes. Under such circumstances the auxiliary

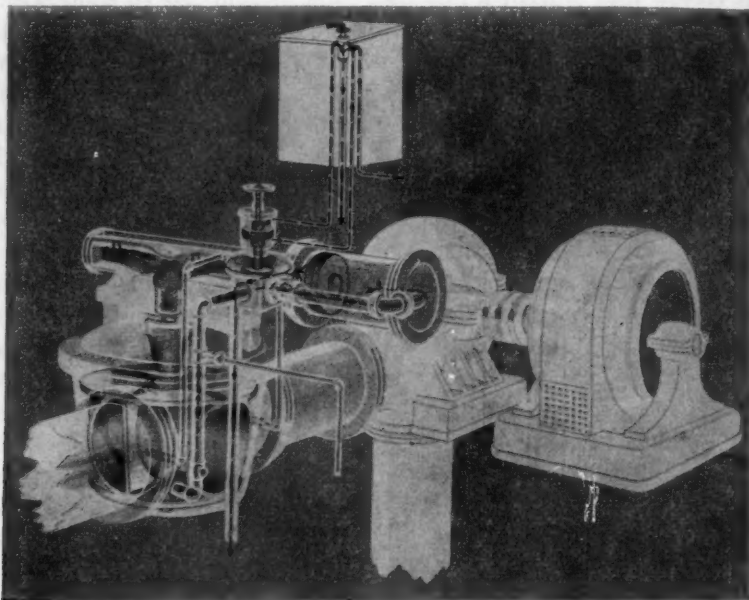


FIG. 2

piston plays no part, regardless of its position, and the outlet pitot connection, with the assistance of a compression spring that always exerts a pull on the pilot valve in the closing direction, takes command of the situation, and at once places the pilot valve in the full closing position. The power water to the operating cylinder flows freely through the check valve which restrains the flow when the valve is opening, and the valve closes quickly and normally, acting as a check.

Another feature of interest in our Vernon Station (fig. 4) is the method we use to insure a supply of pressure water for operating

purposes in the event of a main failure nearby; or should other circumstances cause a drop in pressure so serious as to render inoperative the hydraulic cylinders. In this event the pressure drop causes an alarm bell to sound continuously until the attendant comes to the gauge panel to stop it. Immediately beneath the gauge panel is located the two-way valve shown in this view, the normal position of which is to supply water to the station hydraulic control piping through a connection from the main discharge piping. If the

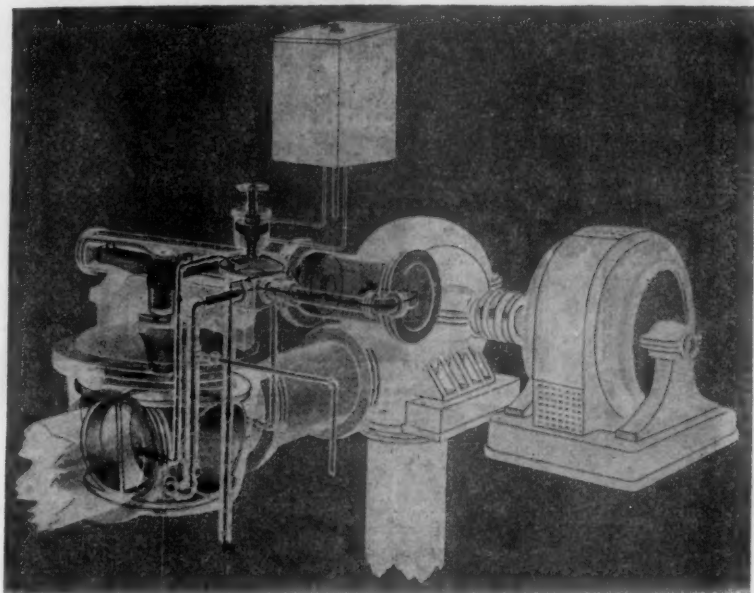


FIG. 3

discharge system pressure is low, a movement of the valve handle cuts off the hydraulic control piping from the discharge system, and connects it to a reserve supply from a water storage tank, the pressure on this supply being of ample value and maintained by the station compressed air system shown. The capacity of the reserve supply is sufficient to operate all hydraulic valves in the station at least once, and the normal capacity is maintained by the float and inlet valve arrangement shown. Replenishment of a depleted storage reserve presents no difficulty against the air pressure, as the

pumping water discharge pressure is somewhat higher than that of the compressed air system, and a special air relief arrangement allows excess air pressure to blow down in the event the volume of air in the tank be sufficient to tend to block the water as it is restored to its normal level. The trapped air in the tank at low water volume is prevented from returning to the compressed air system by the check valve in the air supply line.

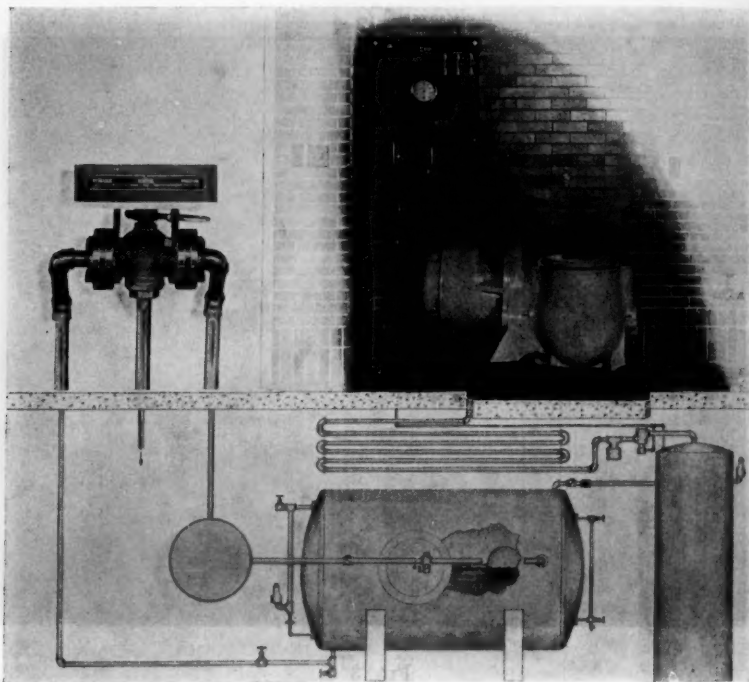


FIG. 4

In the second group of our classification of automatically equipped stations, those full-automatically operated, but with attendant supervision, as exemplified by our Guilford Station, the most interesting feature is the manner in which the starting and stopping is accomplished. The elements of control in their relative positions are shown in figure 5. An understanding of the control system is more quickly grasped if we consider a pump running. The excess of the

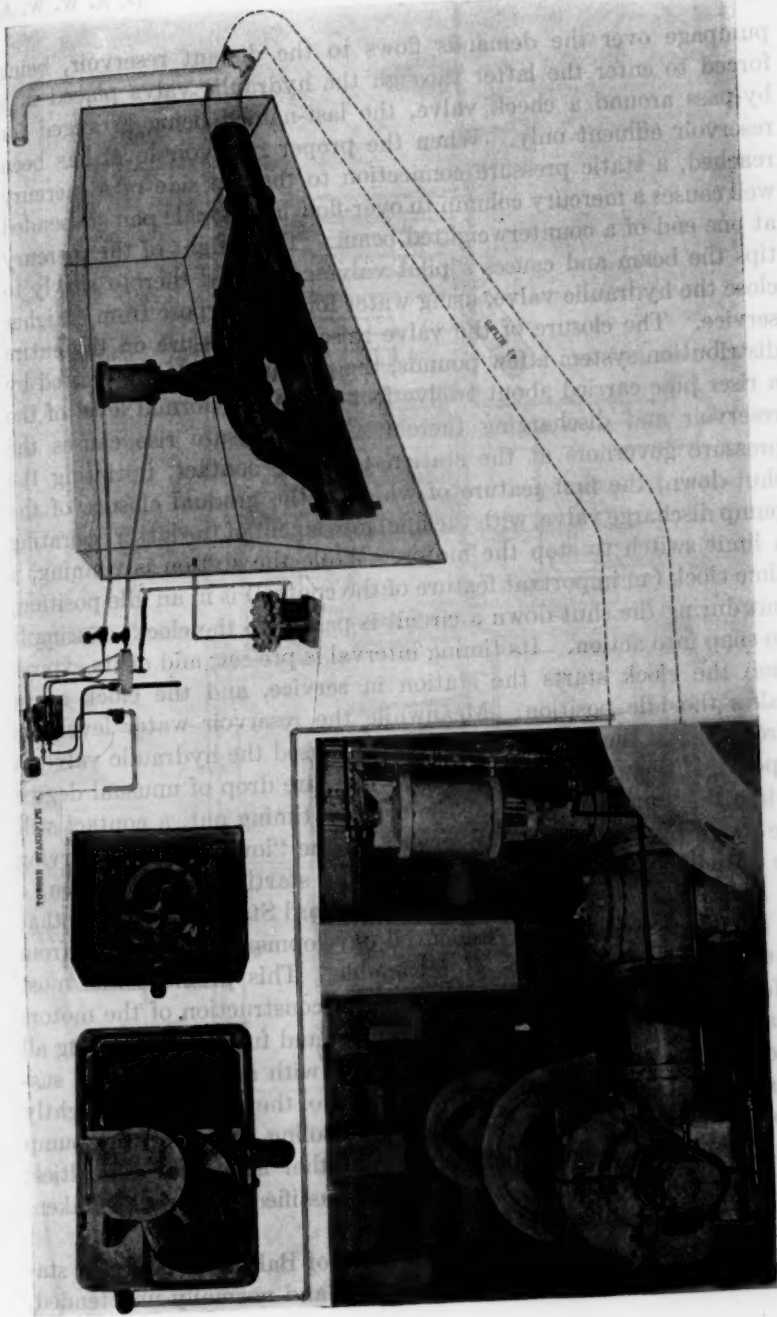


FIG. 5

pumpage over the demands flows to the distant reservoir, being forced to enter the latter through the hydraulic valve placed in a by-pass around a check valve, the last-named being arranged for reservoir effluent only. When the proper reservoir level has been reached, a static pressure connection to the top side of a mercury well causes a mercury column to over-flow into a scale pan suspended at one end of a counterweighted beam. The weight of the mercury tips the beam and causes a pilot valve connected thereto slowly to close the hydraulic valve, using water for this purpose from a higher service. The closure of the valve raises the pressure on the entire distribution system a few pounds, the pressure rise being limited by a riser pipe carried about twelve feet above the normal level of the reservoir and discharging therein. This pressure rise causes the pressure governors at the station to make contact, initiating the shut-down, the first feature of which is the gradual closure of the pump discharge valve, with the final movement of the latter operating a limit switch to stop the motor. While the station is running, a time clock (an important feature of the control) is in an idle position, but during the shut-down a circuit is passed to the clock, causing it to snap into action. Its timing interval is pre-set; and at its expiration the clock starts the station in service, and the clock again takes the idle position. Meanwhile the reservoir water level has dropped and the mercury balance has caused the hydraulic valve to open. If there should be a system pressure drop of unusual degree while the station is idle and the clock is timing out, a contact will be made by the pressure governors on the "low" side, this serving to anticipate the timing of the clock and starting up the station.

Another feature of interest at the Guilford Station is the fact that it is built in a restricted residential development, where noise from the plant would be very objectionable. This problem was most effectively solved by specifying a special construction of the motors that would minimize the windage noises; and further, by placing all the rotative equipment in the basement, with a sound proofed suspended ceiling and with the openings to the upper floor tightly closed. This involved a provision for cooling the air in the pump room during warm weather, and some other incidental difficulties; but the results attained have entirely justified the trouble taken. The station is shown in figure 6.

Of the third group in our classification of Baltimore pumping stations, those fully automatic in operation and normally unattended,

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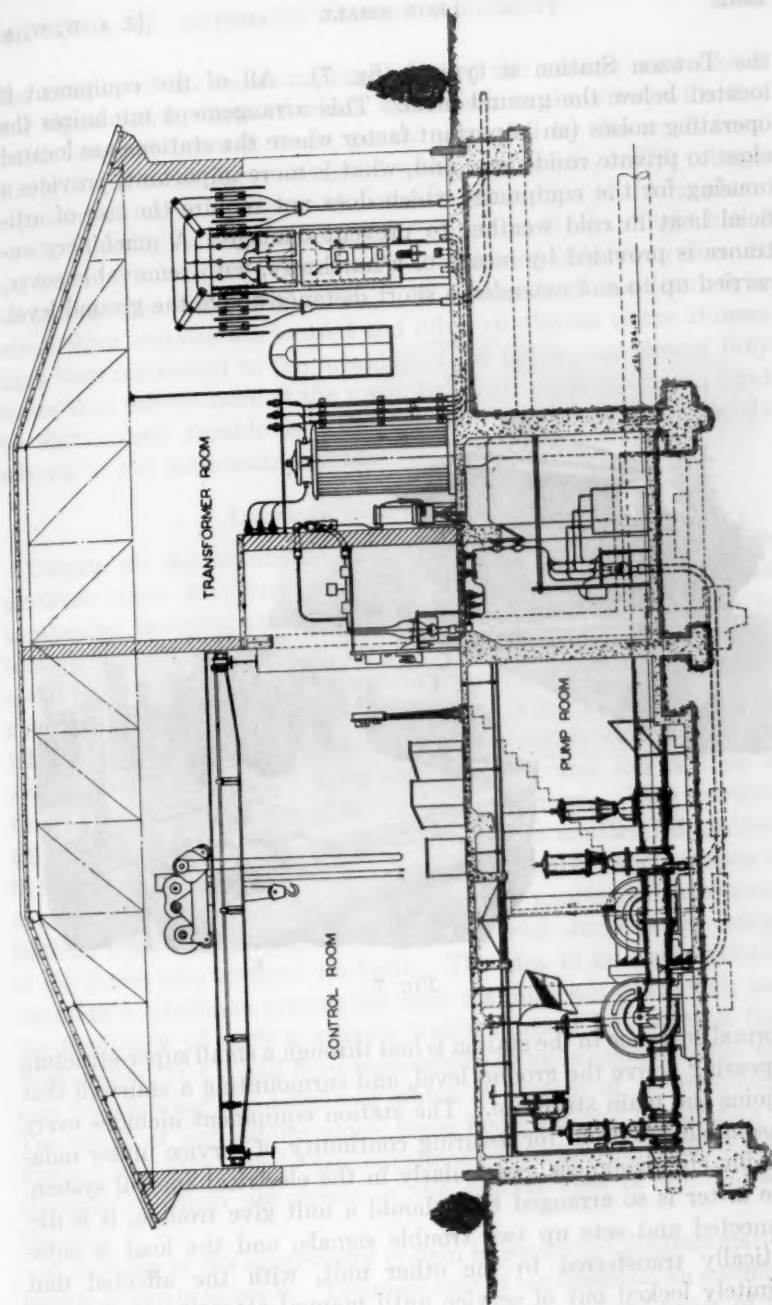


FIG. 6

the Towson Station is typical (fig. 7). All of the equipment is located below the ground level. This arrangement minimizes the operating noises (an important factor where the stations are located close to private residences) and, what is more important, provides a housing for the equipment which does not require the use of artificial heat in cold weather to prevent damage. A machinery entrance is provided by means of a hatchway, with removable cover, carried up to and extended a short distance above the ground level.



FIG. 7

Normal entrance to the station is had through a small super-structure appearing above the ground level, and surmounting a stairwell that adjoins the main structure. The station equipment includes every reasonable provision for assuring continuity of service under unfavorable circumstances, particularly in the electrical control system. The latter is so arranged that should a unit give trouble, it is disconnected and sets up two trouble signals, and the load is automatically transferred to the other unit, with the affected unit definitely locked out of service until manual attention is given it.

The exterior of the super-structure toward the nearest road shows four signal lights, three of which are shown in the view, with the fourth one just beneath them, partly concealed by the small tree. The group of three lights are fitted with green lenses, and if voltage is present on three phases to the station, indication of this is given by the three lights being illuminated. The fourth signal light has a red lens and is normally dark, being illuminated only when there is electric trouble within the station. The foremen of the districts in which these stations are located and other employees of the Bureau have been instructed in the meaning of the lights; and should they notice that one or more of the green lights are dark or the red light be illuminated, trouble is indicated and should be immediately relayed to our maintenance man.

#### *Automatic supervisory system*

Despite all the automatic devices we can install, and the precautions taken to insure continuity of service, the status of an unattended pumping station will always be a matter of concern to those charged with responsibility for their operation. Particularly is this true where the power to the station is supplied by an overhead distribution system. A bad storm or high wind at any time may take down a wire, rendering the station inoperative until repairs are made, the latter probably involving a considerable loss of time in the absence of early notice of the power break-down. This susceptibility to break-down requires that a patrol on unattended stations be maintained at close intervals during bad weather; and a means of obtaining knowledge of the condition of our unattended automatic stations from remote points was given careful study in the design of the latest two stations we built. The idea of an automatically responding telephone system for such stations was conceived; and the feasibility of such a scheme was confirmed by learning that Washington, D. C., had been successfully using telephone-borne signals for showing the height of water in certain of its reservoirs. The result of our studies along these lines was the installation in Towson and Pikesville of our telephone supervisory system, certain elements of which are shown in the general view of the Towson Station.

A close-up of the supervisory system in somewhat diagrammatical form is shown in figure 8. The main unit of the system is an assembly of relays and rotary switches mounted on the control panel of the

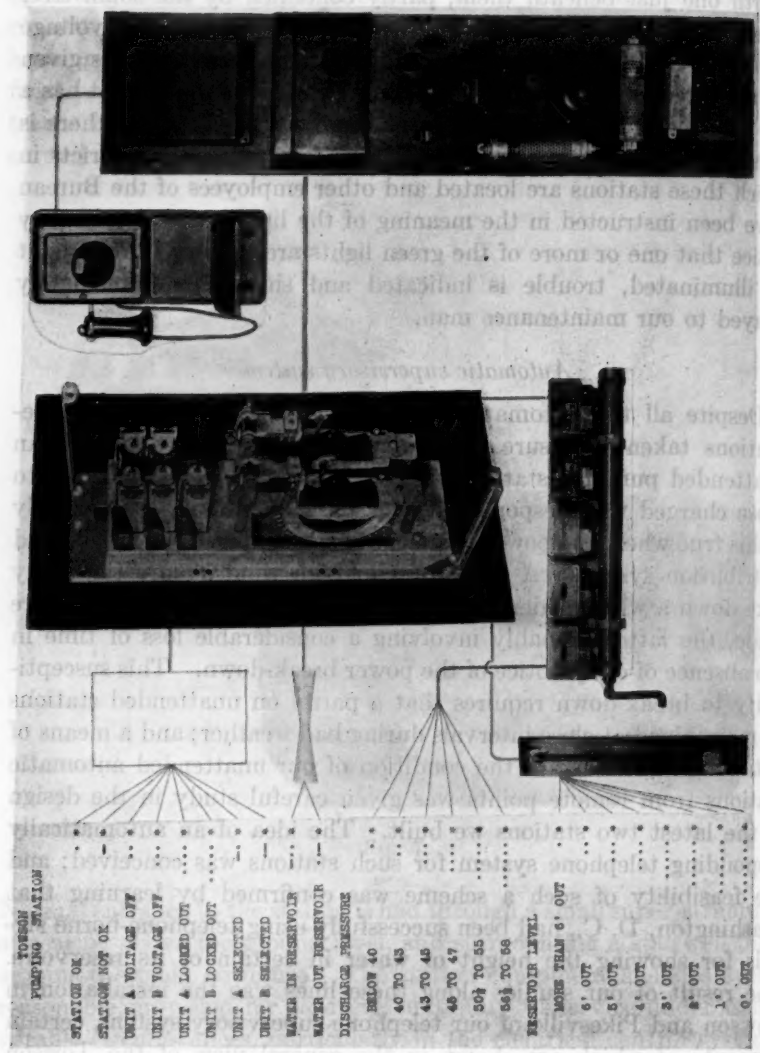


FIG. 8

station and wired to the various elements from which an indication is taken. The energy for the supervisory apparatus is supplied by a 48-volt storage battery maintained by a trickle charger, these not being shown in the view. By special arrangements made with the telephone company, a telephone station with an extension, consisting of a transmitter only, was installed together with certain other special telephone apparatus, the most important of which is a relay which responds when a ringing voltage is impressed on the circuit; and performs a function similar to lifting a telephone receiver, as well as hanging up the receiver when the call is completed. When the station is called, the apparatus responds in a code system of dots and dashes, these being sounded by a buzzer located just beneath the extension transmitter, with a single stroke bell sounding to indicate the termination of each code signal. The first signals sent out concern the electric apparatus only. If this portion of the equipment is in proper working order, the succeeding indications of faults are omitted, but, if the equipment is not in order, this signal is given, and the one or more faults are then coded. Succeeding this set the next signal is then sounded, indicating which of the two units in the station has been selected for service. The next signal shows whether the water is influent or effluent, with respect to the adjacent reservoir from which the station takes it suction; these signals being taken from a movable vane in a double flow Venturi meter through which water to the reservoir is supplied. The next signal shows, within narrow limits, the pressure on the discharge side of the station, these signals being obtained from a battery of Mercoid pressure switches mounted on a manifold connected to the discharge piping. The last signal indicates the water level in the suction reservoir by one foot increments up to a 6-foot limit, the signals being originated by means of a column of mercury balanced against the reservoir level, with contacts set into the mercury column at appropriate intervals. All of the signals are given once, and then repeated, and the special relay previously referred to performs the function of hanging the receiver on the hook, terminating the call. The telephone station can be used for out-going telephone calls; if it is answered while the code signals are being transmitted, the conversation can be continued over the circuit, although the code signals are interrupted.

The results obtained through the use of our telephonic supervisory system have been very satisfactory; and in the belief that a demon-

stration of how the system works brought before you would be of particular interest, arrangements for this have been made by special wire service to Baltimore through the courtesy of the New York Telephone Company and the American Telephone and Telegraph Company. We will call our Baltimore stations and in one of them, the Towson Station, a man has been assigned on special duty deliberately to disarrange the normal status of the station equipment in various ways to indicate how the various signals are received. The large chart is a copy of the Towson code and it has been arranged with signal lights for the purpose of indicating the code signals which we expect to receive from Baltimore, and amplify sufficiently to be audible to all.

## TELEMETERING—THE ELECTRICAL TRANSMISSION OF GAGE AND METER READINGS

BY P. S. WILSON

(Consulting Engineer, Glen Ridge, N. J.)

The word "telemeter," strictly speaking, is not a new word but its use as referred to in this paper, and as now commonly used in the industry, is comparatively new. It combines the Greek word "tele," meaning "far off," with the word meaning "to measure." As in the common use of our familiar words "telegraph" and "telephone," the meaning of telemeter as here used is limited to the *electrical* means of performing the operation, and thus it means to measure from far off electrically—that is, to transmit measurements electrically over wires. These measurements may be any measurements which can be shown on a gage or meter, such as water level, pressure, gallons per minute, volts, valve positions, temperature and others without limit.

The electrical transmission of gage and meter readings is an operation which can be usefully adapted to many kinds of business. Electric light and power companies use it to transmit electrical instrument readings from outlying parts of their systems into central stations, oil and gas pipe line companies find it useful for transmitting pressure and flow indications to central controlling points, gas and steam distribution companies govern the operation of their plants by means of pressures telemetered in from distant portions of the systems, and other uses for telemetering may be found in many other fields. It is the intention in this paper to discuss the subject only with relation to its application to the water works industry and to consider it particularly from the viewpoint of the water works engineer and operator.

The larger part of the development in telemetering equipment has come within the past ten years or so. About twelve years ago, when the writer first had occasion to work with such equipment, there was a very limited choice of types of apparatus or of manufacturers. Even the word "telemeter" had not at that time, so far as the writer knows, been applied to the apparatus. It was simply called a "long distance gage."

There are now at least four to six separate and distinct types of telemetering apparatus, according to the method of classification, and fifteen or twenty different manufacturers with such apparatus on the market. Changes and developments are continuing at a rapid rate. The reason for this rapid development has probably been the growth of need for telemetering incident to the recent development of far flung and inter-connected electric power systems. Certain recent inventions in the electrical field have also made possible several of the types of telemeters which have appeared. These inventions are particularly the synchronous electric motor clock and the vacuum tube. The use of these devices will be noted in the apparatus described farther along in this paper.

The applications and needs for telemetering have existed in the water works field for a long time. Now that electrical engineers have made telemetering practical and popular, these applications and needs are just beginning to be realized by water works men.

It may be well, before going further, to mention another expression often used in connection with telemetering. This is "Supervisory Control." Supervisory Control is generally considered to consist in the performing of operations electrically from a distance, such as operating switches to start and stop motors, operating valves and similar duties. In other words, supervisory control *does things* while telemetering merely provides an indication. The two often go together, most supervisory control systems making use of telemetering as a means of knowing whether the operation has been performed or not. The distinction between the two terms is not always entirely clear.

#### TYPES OF APPARATUS

There are four types of apparatus into which telemetering equipment will here be classified, as follows:

1. "Step by step" type
2. Induction or "position" type
3. Time impulse type
4. Current type and voltage type

This classification is not entirely satisfactory or complete, but it will serve for a discussion of those types of instruments which have been particularly advocated for use in the water works industry. There are some other types of telemetering apparatus which this

classification does not accurately cover, but which need not be further mentioned at this time. Among these is the type of apparatus consisting of sending equipment only and using regular telephone service for the transmission of audible signals. This latter type of telemeter has been most ably described and demonstrated in the paper by Leon Small which appears in this issue of *The Journal*.

In June, 1932, there was presented before the American Institute of Electrical Engineers at its Cleveland Convention a Committee report entitled "Report on Telemetering, Supervisory Control and Associated Communication Circuits." This report lists, classifies and describes in detail practically all of the telemetering equipment which was available at that time. A revision of this report is now in progress. It will, it is understood, be presented shortly and will bring the last report up to date. For many comparative details of the different makes of apparatus, and for other electrical information, this report should be consulted. The present writer will endeavor to describe briefly the four above listed types of equipment from the water works viewpoint and with as little duplication of the above report as possible.

In entering upon this discussion, the author incurs some risk of being thought discriminatory, either for or against some particular makes of equipment. If such appears to be the case, it is entirely unintentional. It has been necessary to choose certain makes of equipment as examples of the various types and, while the names have been omitted, they may be readily recognized. The choice of maker in these cases has been made with no prejudice toward those not selected and, to a certain extent, was dictated by the availability of clear diagrams suitable for use in making the illustrations.

### 1. "Step by step" type

The "step by step" type of telemeter consists of a transmitter which momentarily closes an electrical circuit once for each fixed interval of change in the measured quantity. For each interval of *increase* in the measured quantity, one of two circuits is closed—and for each interval of *decrease* in the measured quantity, the other circuit is closed. The receiving instrument is constructed so that one closure of the "up" circuit acts through a ratchet-like device to step up the indicator one interval of reading, and one closure of the "down" circuit acts in a like manner to step the indicator down one interval.

Suppose, for example, a step by step telemeter were used to transmit water level indications. It might be set so that every one-tenth foot change in the water level would cause an electrical circuit closure. This means that after the indicator has moved, the water level must rise or fall a tenth of a foot before the indication will again change and, if the water level is continuously rising, then the indicator will move up "step by step" a tenth of a foot at a time each time the water level has risen one-tenth of a foot.

Three conductors are needed for this type of telemeter in order to furnish the two circuits required,—the up circuit and the down circuit. Under favorable circumstances, the ground may be used for one of these conductors, thus requiring only two wires.

Interest in this type of telemetering equipment is, to a large extent, historical, although there are some makes of this type still on the market and they are capable of giving good service. This type of equipment was probably the first type of telemeter in use. The writer has made no exhaustive effort to determine who made the first one or when that was done, but one of these gages, manufactured by the late Mr. George E. Winslow of Waltham, Mass., was installed for the New Rochelle, N. Y. Water Company in 1896 and is still operating satisfactorily, indicating the level of water in a standpipe by one-half foot steps at a pump station several miles away. Mr. Winslow was a former Superintendent of the Waltham Water Works. He died in 1926 and his instruments have not been on the market for some time.

The principal objection to the step by step instruments is that if the water level, or other quantity being measured, changes during any interruption in the circuit or during a failure of the source of electricity, then the gage is incorrect until it is again adjusted by comparison between the two ends. Such an interruption may occur without the operator's knowledge, thus giving him an incorrect reading without any warning of that fact. Practically all modern instruments are self-adjusting to the correct reading after any interruption, and most of them will provide an indication of trouble in the circuit which warns the operator of such a condition. These are important advantages.

The step by step feature of the indication is not a great objection, since, theoretically, the steps may be made as small as desired.

The step by step type of telemeter is less complicated electrically than any other type of instrument.

## 2. Induction type

The induction type of telemetering instruments has been on the market for a number of years, but several additional makers have appeared recently and there are probably more different makes of this type than of any other.

There are several subdivisions into which this type of telemeter might be further classified, but the principles, in general, are the same. The apparatus consists of armatures or coils at the transmitting and receiving ends which operate in magnetic fields. By the electrical interconnection of the instruments, the armature at

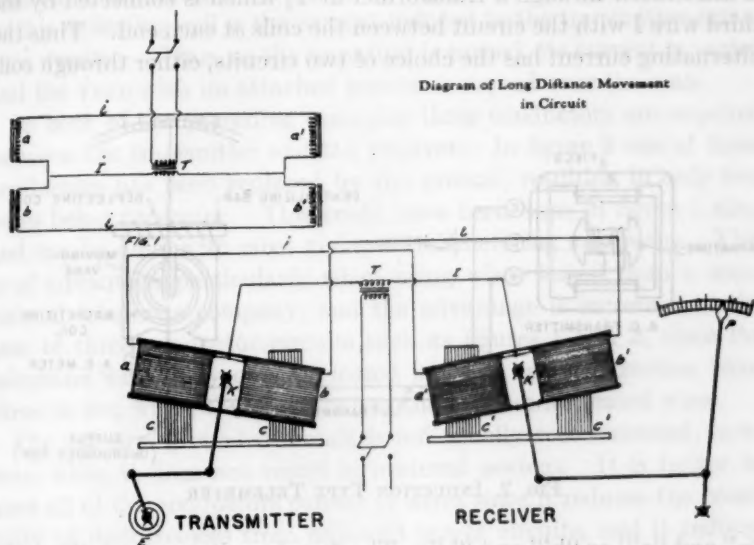


FIG. 1. INDUCTION TYPE TELEMETER

the receiving end is caused to move in a manner corresponding to the manner in which the transmitting armature is moved by the measured force or quantity. This motion of the armature at the receiving end is indicated or registered in a suitable manner by mechanical means.

An example of this type of equipment is shown in figure 1. The transmitting end is at the left and the receiving end at the right, and a simplified wiring diagram is shown in the upper left. The actuating element is shown at E. It happens in this illustration to be the spiral tube of a Bourdon pressure gage. The shaft at E could

just as well be connected to any other operating element, as by gearing it to a float. The only requirement in this and similar cases is that the gearing shall result in a range of motion of the shaft at E which will be suited to the instrument.

In this example the transmitter and the receiver are very similar. Each consists of two coils "a" and "b" mounted on a frame, mechanically balanced and supported so as to rotate in a vertical plane about the center K. The rotation causes each coil to move up and down around a fixed iron core C, thus varying the impedance of each circuit. The coils are all in series and a source of alternating current is introduced through a transformer at T, which is connected by the third wire I with the circuit between the coils at each end. Thus the alternating current has the choice of two circuits, either through coils

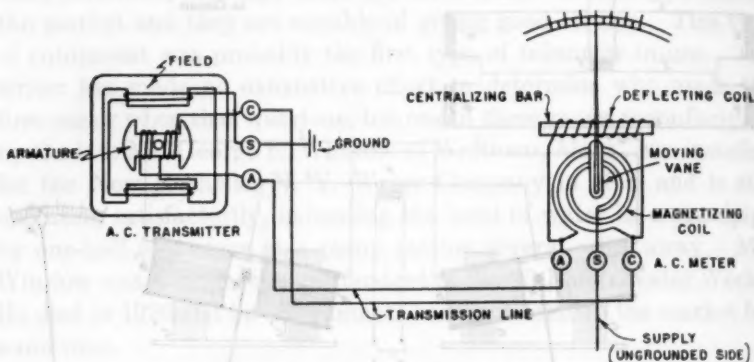


FIG. 2. INDUCTION TYPE TELEMETER

"a" and "a'" or "b'" and "b". The drop in voltage across these two circuits must, of course, be the same and, with the transmitting coils held in a given position, the receiving coils will automatically assume a position so as to accomplish this. Now assume a motion of the transmitter coils counter-clockwise. Coil "a" will move farther over its iron core, increasing its inductance and the total impedance in its circuit, while coil "b" will do the opposite. Less current will flow through "a" and "a'" and more current will flow through "b" and "b'". The result is that the receiver coil "b'" is pulled down over its core while "a'" moves upward until the current flow between the two circuits is again balanced. The consequent motion of the receiver coils is indicated by the pointer "P" upon the scale, which is calibrated to agree with the transmitted quantity.

Another example of the induction type of telemetering apparatus is illustrated in figure 2. The transmitter consists of an iron armature, geared or otherwise connected to the actuating element such as a float or other device. This armature is wound with wire and revolves within a stationary two pole field. The field coils are supplied from an alternating current source, thus inducing a current in the armature winding which varies with the position of the armature with respect to the field.

The receiving apparatus consists of an iron vane which is free to rotate. This vane is magnetized by a coil surrounding it. Its position is determined by the deflecting coil shown, and the current in this deflecting coil is the current induced in the transmitter armature winding. Thus, as the armature is turned, its current is varied and the vane with its attached pointer is moved over the scale.

In both of the preceding examples three conductors are required between the transmitter and the receiver. In figure 2 one of these conductors has been replaced by the ground, resulting in only two wires being necessary. This could have been done in figure 1 also, and can be done with most makes of telemetering apparatus. This is of advantage particularly when using wires leased from a commercial telephone company, and the advantage is increased in the case of three conductor circuits such as figures 1 and 2, since the telephone wires may only be leased in *pairs* and a reduction from three to two wires, therefore, halves the expense for leased wires.

The use of a grounded circuit is not usually recommended, however, when it does not result in material savings. It is better to have all of the conductors consist of wires since it reduces the possibility of disturbances from adjacent power circuits, and it reduces the possibility of trouble due to accidental grounding of a wire circuit.

In figures 1 and 2 the source of power, usually 110 volt alternating current, may be introduced at either end of the circuit or at any one point in between, and if power is available at one end of the circuit, none is needed at the other end.

Still another of the variations of the induction type of telemeter is shown in figure 3. This is often known as the Selsyn system, a trade name. It consists essentially of a small synchronous motor at each end of the line. The shafts of these motors do not revolve continuously but only through a part of a revolution, or a few revolutions, to transmit the indication. As the shaft of the transmitting

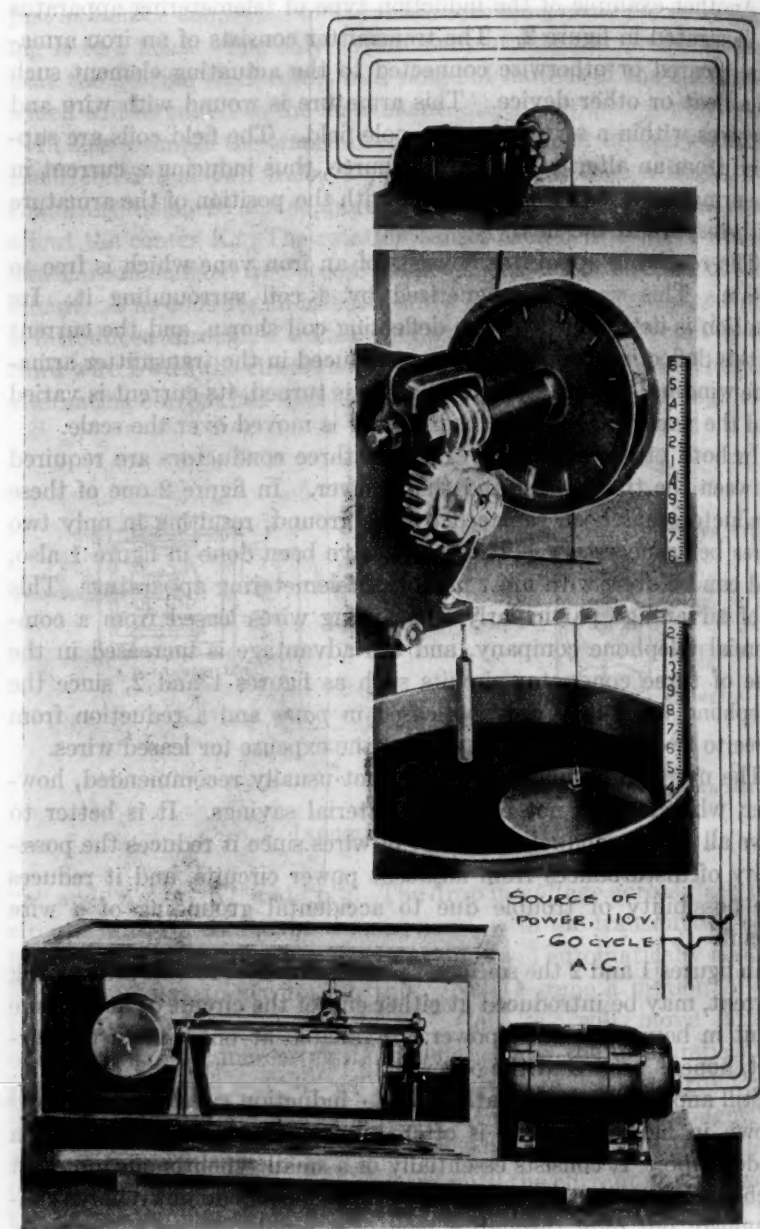


FIG. 3. INDUCTION TYPE TELEMETER

motor is revolved by the float or other actuating element, the shaft of the receiving motor will follow at the same speed and in the same direction. Considerable power may be transmitted from the actuating element to the receiver with this form of apparatus and, in this respect, it is different from most of the others, in few of which the receiving unit can exert more than enough force to move a pointer or pen arm. This apparatus has the disadvantage of normally requiring five conductors between the transmitter and receiver, although if the current supply at both ends is absolutely in phase, only three conductors are required.

As previously mentioned, there are a number of other variations of the induction type of telemetering apparatus, but the examples given will serve to illustrate the principles involved.

### 3. *Time impulse type*

The time impulse type of telemeter is much simpler in theory than the induction type, but the mechanism of the apparatus is generally more complicated. Essentially it consists merely in closing an electrical circuit for a *time* which is proportioned to the quantity being measured. Assume, for example, that the instrument is indicating a reservoir height with a range of 0 to 20 feet, and that the instrument is so built that it transmits one electric time impulse each minute. If the reservoir reading is, say, 5 feet, one-quarter full, then the electrical circuit will be closed for one-quarter of each minute, that is for 15 seconds, and for 45 seconds the circuit will be open. If the reservoir reading is 12 feet, then the circuit will be closed for  $\frac{12}{20}$  of each minute, or 36 seconds of each minute, leaving 24 seconds of open circuit in each time impulse cycle.

The total time impulse cycle, or time interval between impulses, may be varied widely to suit conditions, but it has been usually one minute or one-half minute. If it is one-half minute, then the time impulses are reduced accordingly to bear the same relation to the total cycle interval as does the reading of the gage to the total range of reading.

The transmitting apparatus consists merely of equipment for closing and opening the circuit at regular intervals, leaving it closed for a length of time proportional to the quantity being measured. The receiving apparatus consists of equipment for measuring the length of the electrical time impulse and translating it mechanically into a visible indication on a scale.

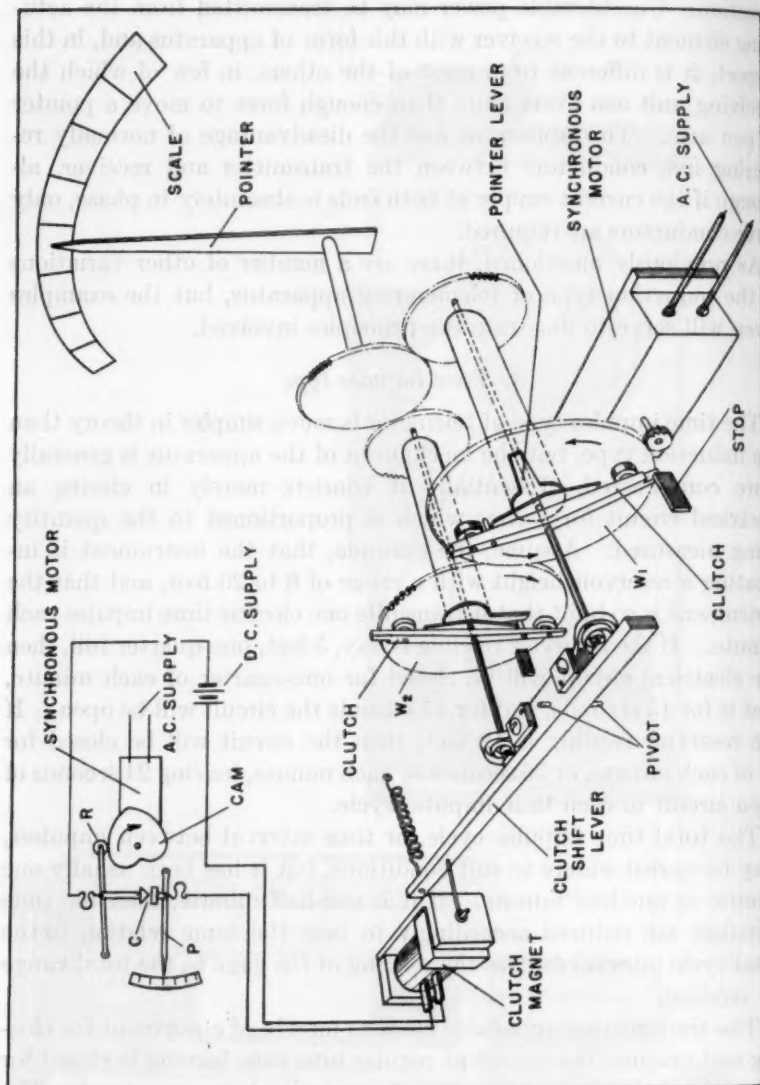


FIG. 4. TIME IMPULSE TYPE TELEMETER

The development of the electrical synchronous motor clock made this type of telemeter possible, since only by that means is it practically possible to run the sending and receiving equipments at exactly the same speed and thereby to keep the cycle of operations at the two points in step with each other.

The approximate manner of operation of a time impulse telemeter is demonstrated in figure 4. The transmitting apparatus is in the upper left and consists of a synchronous motor clock driving a cam continuously at a constant speed, in this case at one revolution in each 30 seconds. Thus the cam rider R is lifted by the cam, and the electrical contact at C is broken, once in each 30 seconds. As the pointer P is moved over the scale by the motion of a float or other actuating device it raises and lowers the contacting elements at C. If the pointer is low on the scale then the cam rider will be lifted, and the contact will be broken, for a large part of the revolution leaving the circuit closed for only a short time. If the pointer is high on the scale then the cam rider will only be lifted for a short time and the circuit will be closed for a large portion of the time impulse cycle. The cam is so shaped that the period of contact and the length of the time impulse will be proportional to the reading of the pointer on the scale.

The circuit carrying the time impulses is a two conductor circuit supplied from a source of D. C. power at any point in the circuit. At the receiving end it acts through the clutch magnet shown to oscillate the clutch shift lever about its pivot, thus causing the clutch on either one or the other of the two large gear wheels  $W_1$  and  $W_2$  to engage with the wheel. If the time impulse current is on, then the magnet pulls the clutch shift lever and the right hand clutch is engaged. If the current is off, then the spring pulls the clutch shift lever the other way and the left hand clutch engages.

The two large gear wheels are driven at a constant speed in opposite directions by the synchronous motor clock. When the clutch on one of them engages, it starts turning with the gear wheel and, when it reaches the pointer lever, it pushes that also, rotating the corresponding smaller gear wheel on the other end of the shaft and through the middle gear wheel turning the pointer. When the other clutch engages, it revolves in the opposite direction and thus, when it reaches its pointer lever, it pushes the pointer in the other direction. When a clutch is released the spiral spring shown returns it to its starting position against the fixed stop, leaving the pointer in the position to which it has been pushed.



thus with a constant reading at the transmitting end, the "up" clutch and the "down" clutch will each tend to push the pointer from opposite directions toward the same reading and the pointer will be left at that position by both clutches. Whenever the value being measured changes, the length of the transmitter contact will change, the length of the time impulse will change, one of the clutches will remain engaged longer and the other for less time, and the pointer will be pushed to the new reading. This "resetting" of the pointer takes place once in each time impulse cycle of operation.

A diagrammatic sketch of another variation of the time impulse design is given in figure 5. The transmitter is in the lower portion and six views of it are shown in successive positions of the time impulse cycle. The cam "b" is revolved at constant speed, in this case one revolution per minute, by the clock motor M. The switch mechanism, in this case carrying a mercury switch "c," rides up and down on the cam hanging from its roller. When it rises to position 2 it picks up the tripping rod "d" by its hook, thus tipping the switch "c" and closing the time impulse circuit. When continued revolution of the cam again lowers the switching mechanism to position 6 the tripping rod "d" again rests on the actuating element, in this case float "e," and the switch tips back and opens the circuit. The portion of the cycle during which the circuit is closed and during which it is open depends upon the height at which the tripping rod is held by the actuating element and upon the shape of the cam. The cam is usually so shaped that the time of contact is directly proportional to the height at which the tripping rod is held, and this in turn is proportional to the value of the measured quantity. The tripping rod "d" may be positioned by any actuating element in place of the float shown in the illustration, the only requirement being that it shall be so geared as to move through the correct range to suit the instrument.

In the case of this particular make of instrument the "up" clutch and the "down" clutch on the receiving apparatus are each operated electrically. The time impulse current acts through the relay switch shown to energize either one or the other clutch, depending upon whether the current from the transmitter is on or off. In an exactly similar manner to the first instrument, one clutch pushes the indicator (which in this case is shown as a pen arm) upwards, while the other tends to push it down, thus resetting its position once each cycle.

It will have been noted from these examples of the time impulse

type of telemeter that a source of 110 volt A. C. power is required at each end of the circuit in order to operate the clock motors. This may introduce a difficulty in some cases since occasionally power is not available at one end. To meet this difficulty, there has been devised a system whereby sufficient A. C. power to run the clock motor may be transmitted over the same two wires which carry the D. C. time impulses. Such an arrangement adds electrical complexity to the apparatus, but the possibility of utilizing it, if necessary, should be borne in mind.

The time impulse type of telemeter has a disadvantage which should not be forgotten,—there may be a lag between a change in the measured quantity and the correct indication of it at the receiving end. This lag may be, in an extreme case, as much as twice the time of the impulse cycle; i. e., one or two minutes. With slowly changing quantities such as most water levels, this is of absolutely no consequence. In most cases pressures and rates of flow do not change quickly or often enough to make this lag objectionable. The other types of telemeters (excluding the step by step) do not, as a rule, have this lag, but provide immediate indication of any change in the quantity measured.

The time impulse type of telemeter has a marked advantage over most other types of telemeters through its electrical simplicity as before noted. This feature is of particular importance to water works men who, as a rule, are not electrical experts. The time impulse type of instrument does not involve delicate and minute variations in current, voltage or phase relation; there is one circuit only and the current is either on or off, and that is the only variation of consequence. This electrical simplicity results in much less possibility of disturbances from other circuits or from accidental variations in the electrical characteristics of its own circuit. It results in a more permanent calibration and less frequent necessity for adjustment in most cases.

Another advantage of the time impulse type of instrument is that a lower current value is needed in the transmitting circuit than for most induction type instruments. Consequently, the allowable resistance of the circuit may be much greater and the limitations as to distance of transmission are almost entirely removed. Many of the induction type telemeters are capable of operating satisfactorily over a distance of only a few miles. With a leased line telephone circuit, the resistance is relatively high and the distance may be limited to

only a mile or two. A time impulse telemeter can operate over practically an unlimited distance.

Most water works telemetering would not require transmission over a long enough distance to make it economical to "simplex" the circuit with circuits used for other purposes or to employ so-called "phantom" circuits. If this should prove economical, the use of D. C. only in the time impulse transmission circuit makes it simpler. The use of D. C. only likewise results in a more advantageous rate classification by the telephone company under the system of charges based upon frequency which will probably be instituted in the future.

#### *4. Current type and voltage type*

The type of telemeter which uses variation of current flow as a translating means and the type which uses variation of voltage as the translating means have been grouped together. These types of telemetering apparatus have been used less frequently for water works installations, but there appears no reason why they cannot be as satisfactory as other types. They share with the time impulse type of instrument the advantages of low current value in the transmitting circuit and the fact that this circuit carries only direct current.

The principal problem in either of these types of equipment is to prevent interference with the reading by variations in the resistance of the connecting lines. The design could be extremely simple if it were not for that consideration. One example of these types of apparatus is given by figure 6 in order to show one of the methods of meeting this condition.

In this illustration the operating element is shown as a pressure gage. It is connected to the equipment by means of a spiral torque spring. The vertical shaft above the spring does not revolve except very slightly, the operating element in its motion merely tightening the spring and exerting a corresponding torque through the upper shaft. As the gage spindle revolves and tightens the spring, the upper shaft is revolved very slightly, turning the mirror so that more light is thrown on one of the two photoelectric tubes. This varies the grid voltage in the vacuum tube or pliotron to which it is connected and causes a corresponding variation in the current output of that tube. This current output acts upon the restraining element at the top to react mechanically against the torque exerted by the spring on the shaft until the system reaches a balance. The restraining element is essentially a direct current ammeter. The torque

of the spring is proportioned to the movement of the operating element and the current which must be applied to restrain that torque is, therefore, likewise proportioned to the movement of the operating element. This current is passed through the external circuit to the receiving instrument which is an ammeter and measures the current. If the line resistance varies, the voltage output of

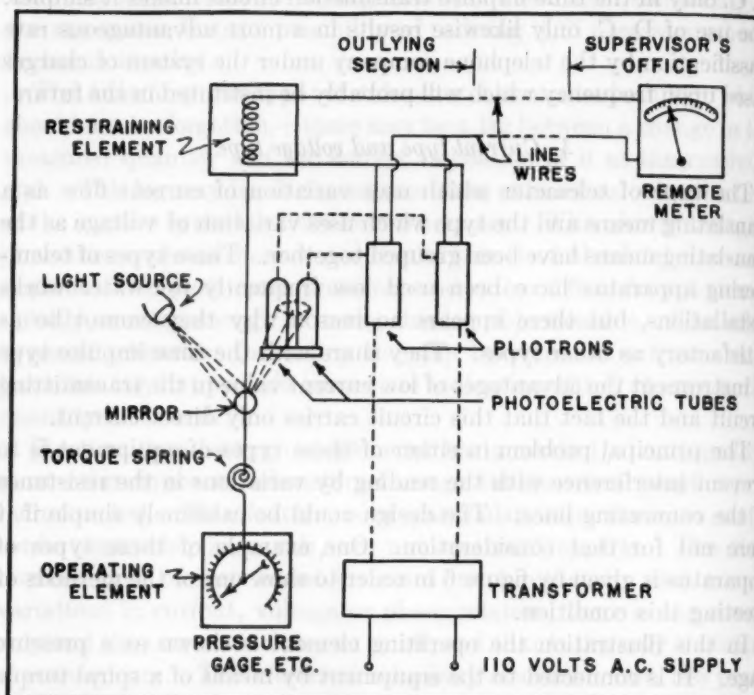


FIG. 6. CURRENT TYPE TELEMETER

the plotron will vary so as to keep the current constant through the restraining element.

In an instrument which uses variations of voltage as the translating means, the voltage impressed upon the transmitting circuit is varied by the transmitting equipment in proportion to the movement of the actuating element. At the receiving end an opposite and counteracting voltage is impressed on the transmitting circuit and this is automatically adjusted to exactly neutralize the voltage from the transmitter. Thus no current flows in the transmitting circuit

and variations in its resistance make no difference. The reading of the receiving indicator is derived from the amount of voltage necessary to be applied at that end in order to counteract the transmitter voltage.

#### GENERAL

As previously stated, the examples of telemetering equipment which have been given have been intended as illustrative only of the principles upon which such equipment has been built. It is hoped that the explanation given with these examples will serve to assist in an understanding of any apparatus which may be encountered, as well as to make clearer the possibilities and capabilities of this class of equipment in general.

Mention has been made of the possible use of leased circuits of the telephone company for use in the transmitting circuits. The advisability of doing this depends upon the circumstances in each case, but, in any event, there is one important advantage of using the telephone company's service for this purpose. That is the fact that the telephone company will in that case perform all maintenance and repair of the line, including constant supervision of it and immediate trouble service when needed. This feature is of particular value to a water works organization which does not, as a rule, have regular employees who are skilled in that type of work.

In the preceding discussion mention has been made only of an *indication* of the reading or measurement at the receiving end. All telemetering equipment may furnish not only a pointer indication, but also a chart record and, if applicable, a total integration at the receiving end. These features merely involve the usual mechanical auxiliaries for their provision.

One fact which deserves further emphasis is the fact that telemetering is independent of the nature of the kind of quantity measurement which is being transmitted. The transmitting equipment may be actuated by a float on water or on mercury, by a pressure gage, by the stem of a gate valve, or by any other moving object. The only requirement is to gear the motion properly so as to suit its range to the amplitude of motion of the instrument. Any change which can be translated into motion can be telemetered and the telemetering equipment is more or less independent of what the actuating element may be. The possible uses for telemetering could, therefore, be enumerated almost without limit.

The most obvious application of telemetering for water works is, of course, the transmission of water level indications from a reservoir or tank to the location of the pumps. By this means the pump operator may know at all times exactly how much water is in storage. He can not only avoid overflows with waste of water and power and possible damage, but he can also make better use of the storage to operate his pumps more economically. He can safely let his reservoir draw down lower, waiting until off peak hours to operate the pumps or using smaller units and creating lower power demands. The system is given greater capacity to meet emergencies since the operator is immediately advised of any unusual draft upon the storage.

In direct pressure pumping systems telemetering makes possible the regulation of the pumps upon the basis of the pressure at any point in the system, and not only by the pressure at the pumping station. This may result in economies in some large systems.

In the operation of large pumping stations or filter plants, it is frequently desirable to have the readings of certain gages and instruments brought to one central control point. This may involve a distance of several hundred feet and make mechanical transmission difficult or impractical. Telemetering offers a ready solution of this problem. Such readings may include not only pressures and water levels, but also the rate of flow readings of meters and the exact position or amount of opening of valves, the speed of pumps and many other things.

#### DISCUSSION

D. J. PURDIE (*Builders Iron Foundry, New York, N. Y.*): The telemetering equipment as designed and constructed by Builders Iron Foundry for the past two or three years comes under Mr. Wilson's classification of "Time Impulse." It gets its name of Chronoflo from the Greek word "Chrono" for time, to which is added the syllable "flo."

The Chronoflo, as applied to metering, consists of a pair of mercury wells, or their equivalent, for receiving the differential pressures, with a transmitting device shown by figure 5 in Mr. Wilson's paper. A simple electric circuit connects the transmitter with the receiving instruments through a relay rectifier device. The receiving gauges may be recording, indicating and totalizing or any combination of these, located at the same or different places. If separately located,

added relay rectifier boxes may be required. Additional gauges may be added to the circuit at any time, or the circuit may be extended, requiring only that arrangements be made for obtaining sufficient voltage to supply the transmitting current impulse.

One mile of No. 22 gauge wire requires no added voltage booster, but greater distances or increased resistance is taken care of by a simple power-pack booster. The transmitting current is 0.030 to 0.035 ampere, but this value is not critical and therefore reasonable variations in voltage, resistance or other electrical values are not of consequence.

Distances over which this system has operated vary from a few feet to 500 miles, but usually are within 10 or 15 miles. There appears to be no limiting distance.

It is important to note that several transmitters may operate over one circuit, either to an equal number of gauges or to a single gauge. This is accomplished by selective equipment. By such apparatus, it is also possible for a central operator to select from which transmitter he wishes to take a reading.

When the line current fails, proper operation is automatically resumed without adjustment or resetting when the time impulses are resumed.

The standard cycles of operation are 60-second, 30-second and 15-second, but actual practice shows that in ordinary cases the 60-second operation is satisfactory. For selective operation, undoubtedly a shorter cycle would be better.

It is true, as Mr. Wilson has said, that the most obvious application of telemetering is that of water levels. There are, however, water works systems where, if they were being built to-day, Venturi Meter readings would be collected at some central point rather than by tedious and expensive daily trips to remote locations. There is no difficulty in doing this or of combining the readings of several meters on one receiver.

For transmitting water levels, three different kinds of pressure responsive devices have been used, all using the same type of transmitter. For water levels below the location of the transmitter, a float and cable operate the actuating device. A mercury column and float balancing the water head are employed where the head is 30 feet or less, and in the case of higher tanks, or on pressure systems, a bourdon tube arrangement, calibrated at the shop for the zero level, does the same thing. The general principle involved is to reduce the

water level or pressure changes to a lineal motion within the range of the transmitter and thus set the actuating mechanism.

This principle applied to the measurement of flow, reporting pressures, levels and positions of valves, covers its chief uses for the water works man, but in other fields, such as the oil pipe line industry, gas industry, steam generating and distribution work, it also finds use. For example, in one gas system, the central operator, by use of the Chronoflo, sets a pressure governor six miles away and receives back a report of the resulting pressure. This illustrates the distinction Mr. Wilson has made between supervisory control and telemetering.

C. A. BUCKARD (*American Telegraph and Telephone Company, New York, N. Y.*): The telephone companies' interest in telemetering and supervisory control is confined to furnishing the means of transmission between the terminal devices supplied by the manufacturers. The telephone companies' offer to furnish such transmission means arises from the fact that their wire plant, both interexchange and particularly the local distribution system, is so extensive that it is natural to expect them to furnish circuit facilities for various purposes outside the scope of the telephone, telegraph and teletype-writer services regularly furnished and, in so far as this expectation can be met without jeopardizing their principal business, the telephone companies are glad to make their facilities available.

In general, the telephone companies' offer is to furnish electrical paths or channels suitable for the required use. The various types of channels are furnished with a definite understanding as to limitation of voltage, amperage and electrical interference incident to the subscriber's usage, the provision of proper protective devices and also as to telephone companies' maintenance and supervisory service anticipated in the basic charges.

The charges for the channels vary as between the Associated Companies, these being controlled by local conditions. They depend on the transmission requirements; on any unusual maintenance or supervisory service required; or battery supply furnished. A charge is also made for any terminal equipment which may be furnished in addition to that normally required to derive the electrical path or channel.

It should be of interest to users as well as to manufacturers of telemetering and supervisory control devices to know that, in general,

where the circuit requirements are for the transmission of only the lower frequencies such as are used in telegraphy, the charges for the channels would be lower than where the requirements are for the transmission of higher frequencies such as are used for voice or sound transmission.

PAUL MACGAHAN (*Westinghouse Electric and Manufacturing Company, Newark, N. J.*): As a member of the Instruments and Measurements Committee of the A. I. E. E., and of its Subcommittee on Telemeters, I was especially interested in Mr. Wilson's excellent presentation of the subject applied to water works conditions. I hope Mr. Wilson will favor this Subcommittee with any data he has which will assist in their present work of revising the previous tele-meter report. The committee is especially interested in telemetering of non-electrical quantities—such as, water level, pressure, etc.

It is true that there seem to be too many different principles of operation. However, the choice of a telemeter will be almost surely dictated by available line or communication channel conditions. The actual total cost of a telemeter system includes the cost of the lines and the rent or upkeep, and this is the major cost, the cost of the apparatus being secondary in value.

Thus it will often be found that the more expensive apparatus which requires fewer or simpler connections will be cheaper as a whole.

The general class of current type telemeter is being rapidly developed in new and improved forms. The latest of these is the new electronic telemeter, a paper on which is being presented at the June, 1934, Hot Springs Convention of the A. I. E. E.

FRANCIS A. HEINE (*Distribution Engineer, Bureau of Water, Reading, Pa.*): Water works may, in general, be said to consist of a number of sources of supply, and a distributing system in which there may be several reservoirs or standpipes, together with means for the periodic or continuous transfer of water from one separated service to another.

In many well regulated water systems more or less complete metering is conducted: readings of supply flow meters and measurements of reservoir content are taken possibly a number of times daily, from which computations are made for storage and consumption. Common results are rates of flow, quantities, etc., by twelve hour periods, arrived at on the day following the period. Such infor-

mation is most excellent for record purposes, and when supplemented by continuous communication with the various parts of the system, affords a good basis of data upon which to regulate the plant.

The advent of practical telemetering devices, coupled with means of transmission at reasonable costs, has made possible the consider-

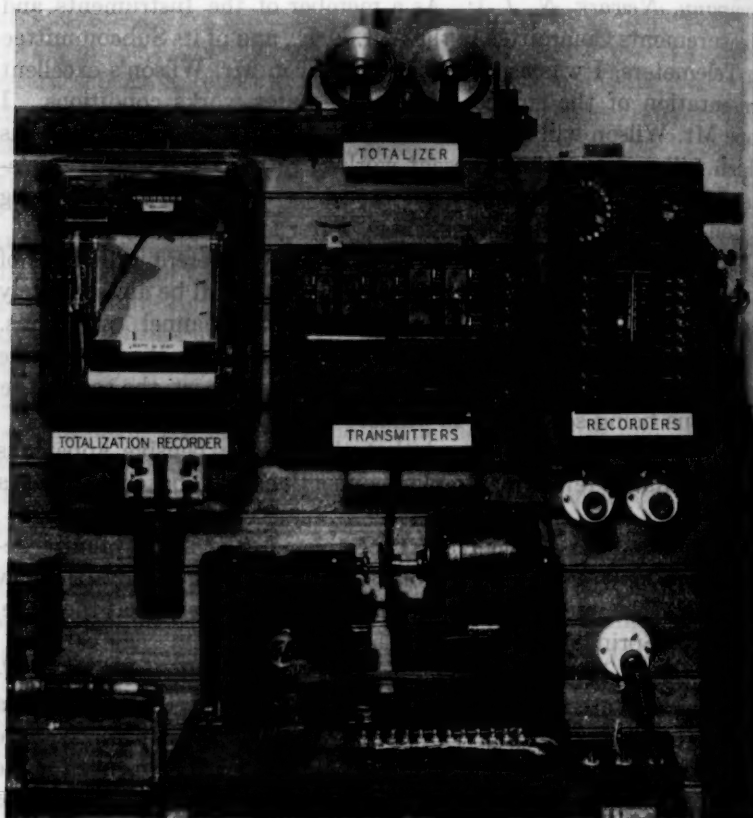


FIG. 7

ation of centralized telemetering for entire systems. Centralization of supply and storage readings will furnish the information necessary for complete manual or automatic control, as well as produce ideal records; and further, by the addition of summation devices, would make available extremely valuable and timely knowledge for oper-

ating purposes, that is: the continuous and automatic indication and registration of totalized water supply, storage and consumption.

Figure 7 shows a working model which I have developed and constructed as a scheme for Totalization of flows in the water system of Reading, Pennsylvania.

The same mechanisms shown on figure 7 are rearranged to show sequence of operation in the model in figure 8. At the left are the transmitters with control, which are arranged to simulate flows from two sources of supply, one distributing reservoir, and two points of

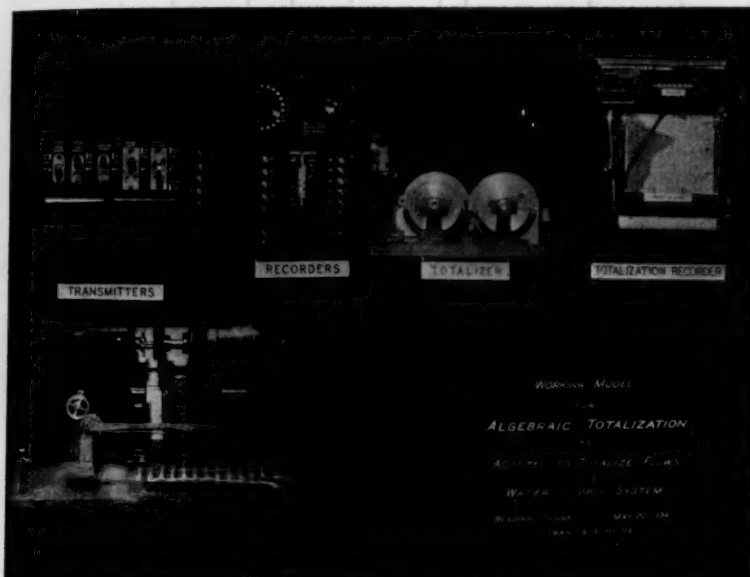


FIG. 8

transfer. For example: when the fifth lever or key is in the upper position, "positive" electrical impulses are caused to be transmitted at intervals corresponding to an inflow at the rate of 2 million gallons daily, to the Hampden distributing reservoir. With this key in the lower position, "negative" impulses are transmitted, corresponding to an outflow at the rate of 4 million gallons daily. The other keys operate in a similar manner, and relate to the 4 other points of measurement of supply or diversion.

The totalizer is a device which concurrently and algebraically adds, and integrates or gives the total of, the various flows.

Another view of this Algebraic Totalizer is shown in figure 9. It is a mechanical type totalizer, actuated by electrical impulses, uses pyramided differential gearing, and is arranged so that the flows at the transfer or diversion points, and of the rising reservoir are represented by "negative" movements which are accumulated until canceled by a like magnitude of "positive" movements. In this manner the surplus "positive" movements only are retransmitted. They represent the total consumption in a distinct but major part of the system, and are recorded on an impulse demand meter.

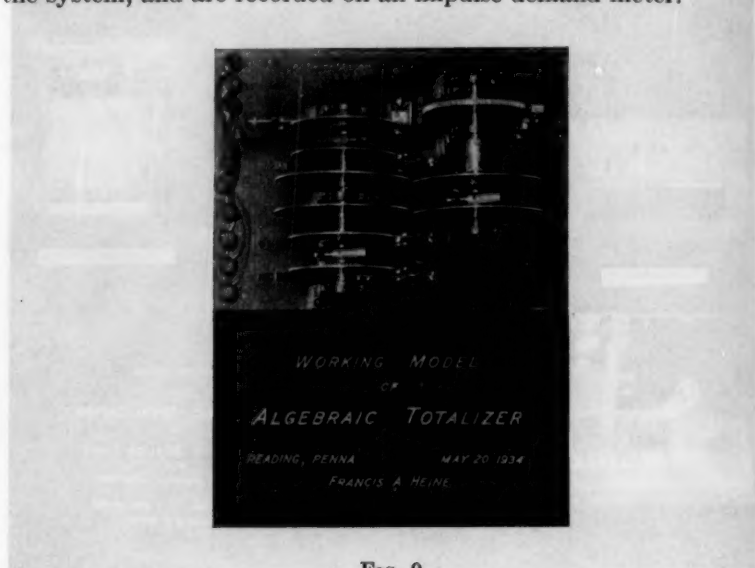


FIG. 9

Although either continuous or step-by-step methods of transmission and registration may be totalized in this manner, the impulse type was selected in constructing this model, because of availability of mechanical parts.

By extending this application of totalization of flows to the remaining parts of the water system, perfectly coördinated metering and totalization will be had.

It would incidentally produce records similar to that shown in figures 10 and 11, which, however, were drawn from data obtained by flow meters and gages located at the points of measurement.

Certain parts of the above scheme of central telemetering are installed in actual remote service, and include a potentiometer type recorder-controller and time switch, for the remote and automatic control of the water level in a high service distributing reservoir, by operation of an unattended pumping station at night, but also during periods of excessive draft; a beam type pressure transmitter, arranged with suppressed zero, and capable of recording fluctuations in head due to friction losses, of the order of 2 tenths of a foot, over a range of 50 feet; and a centrifugal type flow meter, for measuring water at a filter plant 3 miles distant.

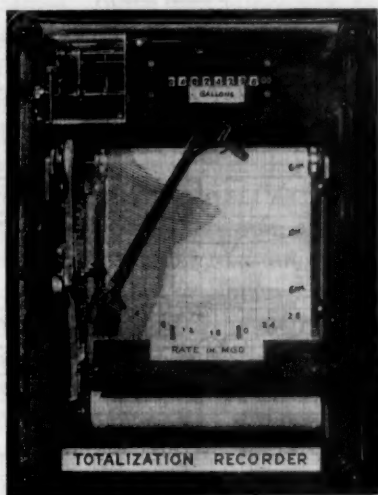


FIG. 10

Leased telephone pairs are used for the transmission circuits. The cost of them is at the rate of \$3.50 per month per air line mile, and the maximum current allowed is 350 milliamperes at 120 volts. With the exception of transmission circuits and power requirements, the cost of service maintenance on our telemeters, based on one year's operation, does not exceed that of the conventional type of mechanical or electrical meter.

It is the intention of the Reading Water Department to ultimately attain universal telemetering, including distribution system pressures; and in doing so, generally to utilize superposed telephone circuits.

# GRAPHICAL RECORD OF SUPPLY AND CONSUMPTION OF WATER BY SERVICES FOR ONE WEEK, BEGINNING 6 AM THURSDAY OCTOBER 22, AND ENDING 6 AM THURSDAY OCTOBER 29, 1931 STANDARD TIME

ALL DATA BASED ON CHARTS FROM CONTINUOUSLY RECORDING INSTRUMENTS

BUREAU OF WATER  
READING, PENNA.  
A. B. GREGG, Chief Engineer  
F. A. NEWMAN, Distribution Engineer

NOVEMBER 1931

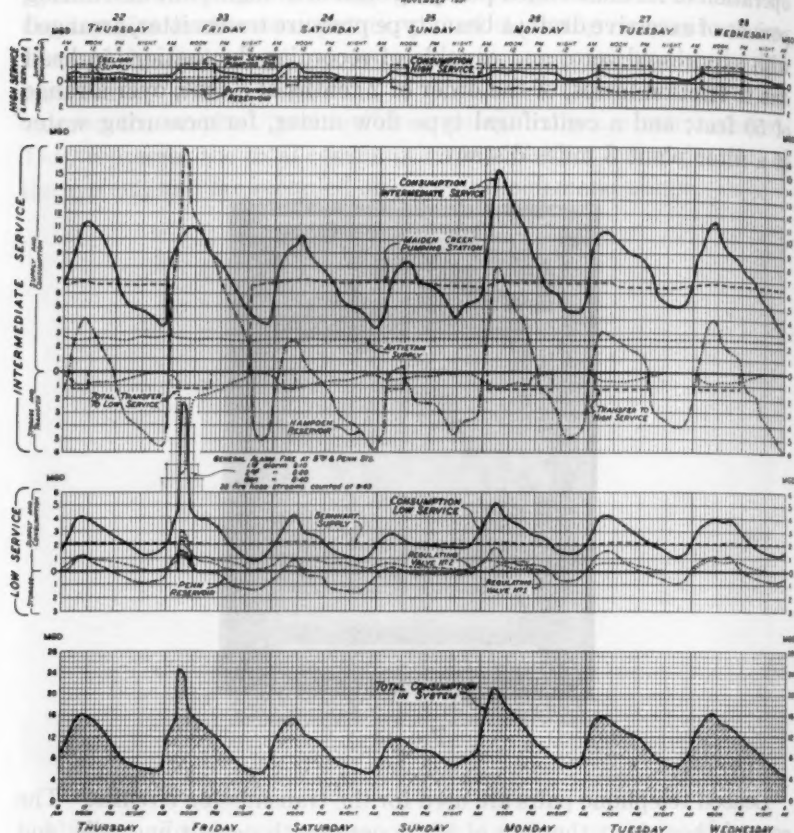


FIG. 11

J. WESTFORD CUTLER (*Engineer, Wallace and Tiernan Company, Newark, N. J.*): I listened with considerable interest to the papers just presented by Mr. Small and Mr. Wilson. During the last few days, I have been in attendance at the Wallace & Tiernan exhibit where one of the Telemeters of the time impulse type (figure 4), which has just been described, is on view. The unquestioned interest which this exhibit has aroused in many of the spectators, coupled

with the information brought forth in these papers, has further crystallized my belief that there is a very definite field for telemetering on water supplies.

In like manner to Mr. Wilson and in the interests of the Wallace & Tiernan Telemeter, I have studied the various instruments available to the water works industry. We realize that electricity means a great deal to every water supply system and that increased uses are continually being brought forward. This is naturally coupled with an increase of electrical knowledge on the part of the management, but nevertheless, the simpler the telemetering system, the more practical it becomes. With this simplicity as a fundamental assumption, I believe that the time impulse type will eventually become the leader, for the following outstanding reasons:

(1) *Lack of interference from electrical disturbances.* A change of resistance, an induced voltage, minor ground potentials and like disorders which are common to long distance transmission lines do not interfere with the performance of this type of telemeter.

(2) *Simplicity.* The wiring diagram of the Wallace & Tiernan time impulse telemeter is similar to a door bell; there are no relays, extra contacts, vacuum tubes or similar accessories fundamental to the operation of the ordinary telemeter installation.

(3) *Ease of maintenance.* This telemeter because of its non-inductive nature is the simplest to maintain, inasmuch as units may be removed, replaced or by-passed without danger of disturbing the proper relation of sending and receiving instruments. Power failures result in no errors once the power is resumed.

(4) *Associated features.* If the time impulse telemeter is constructed so as to provide an unoperative section at the bottom and top of the scale, certain telltale devices can be incorporated in a standard installation to indicate valve openings and like items. This feature will also indicate respectively short-circuiting or open circuiting of the transmission line. Controls and alarms may also be conveniently installed.

(5) *Adaptations.* In addition to the uses mentioned in Mr. Wilson's paper, we may add such items as loss of weight and chlorine flow which are of vital interest to the water supply engineers.

I should like to stress a feature which Mr. Wilson has mentioned in regard to the time impulse type, and that is the fact that alternating current is not necessarily required at the sending point, and that this feature greatly increases the scope of the instrument.

By suitable rectifier and filter equipment both AC and DC can be sent over the transmission wires, the former to run the synchronous motor and the latter for the metering.

Another point which has not been mentioned, should be stressed. On a single pair of wires, the manager may provide himself with a suitable telephone system as well as a first class telemetering system.

## BUDGET FOR YEAR 1934<sup>1</sup>

	<i>Operating Budget</i>
1. Convention Expense.....	\$4,500.00
2. Office Expense.....	5,500.00
3. Committee Expense.....	2,750.00
4. Section and Division Expense.....	2,500.00
5. Directors' Meetings.....	1,500.00
6. Salaries.....	22,200.00
7. Printing Journal.....	17,500.00
8. Reprints and Specifications.....	900.00
	<b>\$57,350.00</b>
9. Membership Dues (Construction League of the United States, July 1, 1934 to December 31, 1934).....	150.00
<b>Total Operating Budget Accounts.....</b>	<b>\$57,500.00</b>
	<i>Extraordinary Expense Budget</i>
Printing Appendix 1 of the Manual.....	\$50.00
Publication of Index to Proceedings.....	1,645.00
Publication of Report of Committee 5 (Quality and Treatment)...	1,660.00
Publication of Census of Water Purification Plants (less sales)...	70.00
National Recovery Committee for Water Works Construction....	2,750.00
<b>Total Extraordinary Budget Accounts.....</b>	<b>\$6,175.00</b>
<b>Total Budget Accounts.....</b>	<b>\$63,675.00</b>

<sup>1</sup> Adopted by the Board of Directors at a meeting on June 4, 1934.

## DISCUSSION

### DEFECTS OF RESIDUAL CHLORINE CONTROL

An article by Nachtigall and Ali, published in the April, 1934, number of The Journal begins by this sentence:

*The maintenance of 0.10 to 0.20 p.p.m. residual-chlorine, detectable by ortho-chloridine test, 10 to 20 minutes after chlorine application, insures the continuous and effective removal of disease-producing bacteria.*

The beginning of the third paragraph of the first page follows:

*The method of Bunau-Varilla differs from this approved AXIOM, in that it disregards the chlorine demand of the water and attributes the greatest importance to a vigorous agitation accompanying the chlorine application. By this agitation Bunau-Varilla reports being able to sterilize clear water with 0.10 p.p.m. chlorine and, slightly turbid water with 0.20 p.p.m. Owing to the action of chlorine on the organic matter present in the water, invisible bactericidal rays are supposed to arise.*

The juxtaposition of the first paragraph of the article and of the beginning of the third one hereabove reproduced gives a perfectly clear contrasting view of the two methods used for the purification of the water by chlorine.

The old one, which is dubbed the "axiom" in the article, requires incessant analyses of the water in order to obtain the quantity of chlorine which, if mixed with the water, will leave after 10 or 20 minutes a free chlorine residue, of 0.10 or 0.20 p.p.m. after the chlorine demand of the water is satisfied. With this residue the water acquires a very bad taste and trouts are unable to live in it. Consequently the laboratory is further led to determine the quantity of the chlorine absorbing body, generally hyposulfite of soda, which, after being mixed with the water will wipe out the bad taste and permit trouts to live in it.

Thus the old system, the AXIOM, is obliged constantly to appeal to laboratory experiments and to a couple of treatments for obtaining a purified water without bad taste, and its correlative trout killing characteristic.

If the laboratory does not guide the chlorine treatment in terms of

the quantity of organic matter present in the water, the chlorine-demand is bound to be either undersatisfied or oversatisfied. In the first case a part of the water will retain its disease-producing bacteria, while in the second case there will be an excess of chlorine residue which will not be eliminated by the chlorine absorbing body mixed in the usual proportion with the water after chlorine treatment.

Thus the *axiomatic* method is constantly in danger of falling either into the abyss of insufficient purification or of a repugnant taste given to the water. Therefore, the guidance of the laboratory is necessary at every moment.

The *Bunau-Varilla method* otherwise known as *Verdunisation*, the principles of which were discovered and put in application during the battle of Verdun by the undersigned, is free from these great handicaps.

The quantity of chlorine used being very much inferior to the chlorine-demand is readily and immediately absorbed and no bad taste can be generated. Furthermore, the quantity of chlorine is independent of the quantity of organic matter present in the water, as the destruction of disease carrying microbes is caused by ultra-violet bactericidal rays emitted by the reaction of particles of chlorine coming into contact with some elements of the organic matter of the water.

This interdependence between the quantity of chlorine and the quantity of organic matter present in the water has the very important consequence of eliminating all laboratory experiments and to cause the adoption of fixed doses of chlorine much lower than those giving a chlorine taste to the water.

In clear water the chlorine dose of 0.10 p.p.m. is always sufficient to destroy all the coli-bacilli, without generating any bad taste in the water. Consequently this dose destroys the typhoid and dysentery bacteria which offer less resistance than the coli-bacilli to the antiseptic action of the chlorine, if applied as the Verdunisation requires.

But in clear water it is very easy to diminish the fixed dose of 0.10 p.p.m. The great town of Lyon (570,000 inhabitants) uses only 0.05 p.p.m. chlorine in its Verdunisation appliances. The town of Dieppe uses 0.02 p.p.m. and its 16,000 cubic meters daily consumption (550,000 cubic feet) are admirably and instantaneously purified for an expenditure of 13 American cents every day without any laboratory.

As to the trouts, they thrive in verdunized water. In the Pyrenees the town of Bagnères-de-Bigorre, where many houses have a trout

pond with flowing water, has verdunized its waters coming from mountain stream. Neither the trouts nor the inhabitants ever remarked a change in the water after Verdunisation was established.

Referring again to the article of Nachtigall and Ali we copy what follows the passage above reproduced of the third paragraph:

*Bunau-Varilla experiments, however, are still not convincing and it would seem that the strong agitation produces no other effect than a more thorough mixing of the chlorine with the water.*

This passage is ambiguous. Which of the *Bunau-Varilla experiments* are still not convincing in the opinion of Nachtigall and Ali?

Do they mean by the words "*Bunau-Varilla experiments*" the process of purification itself by the combination of strong agitation with the use of doses of chlorine very much smaller than the chlorine-demand of the water or do they mean the explanation which I gave of that curious and hitherto unnoticed or, if not unnoticed, at least unpublished phenomenon.

If they meant by "*Bunau-Varilla experiments*" the new system of water purification, the "Verdunisation," it seems strange that the authors instead of writing that these *experiments are not convincing* have not shown experiments contradicting explicitly these "*Bunau-Varilla experiments.*" Undoubtedly these authors have begun their study of the new process by laboratory verifications. If these verifications had failed, the authors would have shown that the method of *Bunau-Varilla* did not exist in practice.

The fact that the authors say nothing of the sort shows that their doubt, their lack of conviction, does not refer to the *Verdunisation* itself, but to the explanation I gave of the mechanism of the phenomenon.

It would have been indeed a difficult task for the authors to cast a doubt on the efficacy itself of *Verdunisation* for purifying the water carrying disease-producing bacteria.

Since its discovery in 1916, on the Verdun battlefield and its application to the army then; since its first application to the municipal service at Reims in 1924, on the initiative of Dr. Téhoueyres, chief of the Hygiene service of that town, the *Verdunisation* in spite of the irreducible opposition of many faithful servants of the old method, whom no proof however striking could convince that their "*axiom*" was soon to be a thing of the past, that it was but a setting Sun, the "*method of Bunau-Varilla*" as Nachtigall and Ali call it has

received innumerable applications in the four continents, everywhere crowned with brilliant success.

In France the town of Paris employs the "*Verdunisation*" for purifying the raw river waters pumped for washing streets and other municipal and industrial uses, and also the *Verdunisation* apparatus for a part of its filtered river water.

The second capital of France, Lyons, purifies the water distributed for human consumption with *Verdunisation* at a dose of chlorine equal to 0.05 p.p.m.; Dieppe uses only 0.02 p.p.m. The towns in France or outside use in general 0.1 p.p.m. or less in clear waters. Among the vast number of them let us mention in France outside of Paris, Lyons and Dieppe; Reims, Bar-le-Duc, Carcassonne, Vichy, Nevers, Cosne, Auxerre, Albi, Cambrai, Sables d'Olonne, La Rochelle, Toul, Evreux, Calvi, Elbeuf, Vendôme, Chantilly, Langres, Chateaudun, Cahors, Libourne, Montauban, Saumur, Avesnes, Montbrison, Boulogne-sur-mer, Bagnères-de-Bigorre, Saintes, Mont de Marsar etc., etc.

Let us mention in Belgium: Bruxelles; in Switzerland: Geneva and Lausanne; in Italy: Genoa and Trieste; in Spain: Sevilla; in Portugal: Lisbon; in Algeria: Algiers; in French west Africa: Dakar; in Cochin China: Saigon; in Venezuela: Caracas.

This list of towns shows that the official services of hygiene in many countries of Europe, Africa, Asia and America have been called upon to judge the efficacy of *Verdunisation*.

Their sentence has been the adoption of the system of purification in preference to all others including the one the rules of which were held as an "*axiom*" formerly.

To this list of towns, of course, could be added not only many other towns, but also an enormous quantity of public or industrial or mining establishments which employ *Verdunisation* with gratifying success without using any laboratory.

The consequence of this enumeration is that Nachtigall and Ali did not probably speak of the efficacy of the "*method of Bunau-Varilla*" where they said "*Bunau-Varilla experiments are still not convincing.*"

Otherwise they would have to say how many public testimonies in addition to those mentioned hereabove are necessary to convince them.

Most probably their remark applies not to the system itself, but to the explanation I gave of the mechanism of the phenomenon.

This is, however, a minor question and I am quite ready to accept another explanation if Science brings me one tomorrow of the phenomenon which presents so many striking advantages.

For the time being I think the best explanation of the extraordinary fact on which *Verdunisation* was based is the following: the destruction of the major parts of the infectious bacteria is effected by ultraviolet rays emitted by the chemical reaction resulting from the contact between the organic matter of the water and the particles of chlorine distributed in the whole mass of water by the violent agitation to which it is submitted. The rest of these bacteria is destroyed by the direct contact between them and the particles of chlorine, which they happen to meet.

To sustain these views there are three capital experiments, every one of which was the object of a communication to the Academy of Sciences of France.

The first I conceived was effected by Dr. Techoueyres. I thought that if ultraviolet rays were emitted by the agitation of water carrying organic matter at the moment of the introduction of chlorine, these rays could penetrate a quartz tube containing water loaded with colibacilli and consequently destroy at least a part of them.

Dr. Techoueyres made 69 experiments and registered an average destruction of 29.96 percent of the colibacilli. After modifying somewhat the conditions of the experiment he made 17 others which gave him an average destruction of 24.60 percent.

This is the first, and for me the most convincing, experiment which demonstrates the presence of ultraviolet rays in the *Verdunisation*.

Somewhat later a scientist, Mr. Mallet, made ultraviolet rays visible during the reaction of hypochlorite of soda on a certain organic matter: urea. This is an obvious proof of the emission of ultraviolet rays during the chemical reaction of chlorine on organic matter.

Somewhat later still three distinguished scientists Mr. and Mrs. Magrou of the Paris Pasteur Institute working, with Professor Reiss of the University of Strasburg, observed a remarkable fact. The oxidation of sugar by permanganate of soda, if effected in contact with a quartz vase where the eggs of sea-urchins were developing new beings caused a striking and a normal modification of their form.

The oxidation of sugar is thus demonstrated to emit certain rays, which penetrate quartz and consequently have the character of ultraviolet rays.

On the other hand, there is in the attack of organic matter by

chlorine a phenomenon of oxidation. Therefore the emission of ultraviolet rays in "*Verdunisation*" is for the third time established by the experiment of Mr. and Mrs. Magrou and Mr. Reiss.

These successive experiments seem to me perfectly convincing, but I admit readily that they may fail to convince other people.

This is why I would gladly accept another explanation, such as Mr. Reiss evolved some time ago, and on which I cannot insist by fear of extending too much the size of this note.

#### THE MAIN OBJECT OF THE STUDIES OF NACHTIGALL AND ALI AND THEIR RESULT

The object of the authors is obviously to demonstrate the truth of the sentence which follows the last one quoted in this note.

*Investigation of the method of Bunau-Varilla shows that one can disinfect certain waters by applying only part of the known chlorine-demand, EVEN WITHOUT AGITATION.*

The authors have been evidently puzzled by the results of the method of Bunau-Varilla just as physicians and chemists were puzzled by the discovery of those mysterious bodies called *Vitamins* which were demonstrated to exert such vital influences on health and life of all animals and which challenged all attempts of chemical analyses.

The case of *Verdunisation* is similar. In both, certain rays of light play an essential part.

However, it seems plain that the customary chemical conceptions of Nachtigall and Ali led them to imagine that (1) *Verdunisation* was effective only in *certain* waters, and (2) also certain waters can be found or certain solutions prepared which will be sterilized by the small doses of *Verdunisation* but *without agitation*.

The answer to the first assumption is the universal success of *Verdunisation* in the four continents. This demonstrates that if certain waters only could be sterilized by *Verdunisation*, that type of water is met everywhere. Consequently, what the authors of the article call *certain* waters is the water pure and simple which is found on all the four continents of the northern hemisphere.

The answer to the second assumption is obvious. It is easy to imagine a water artificially produced or a solution which can be sterilized by infinitely small doses of chlorine *without agitation*.

It is sufficient to have a water containing very little chlorine absorbing element outside of the microbes to be destroyed. Very

small doses of chlorine if introduced in such a water will subsist a long time in the state of freedom and owing to the Brownian movements the microbes will successively be met with chlorine and destroyed as time goes. But a great difference with *Verdunisation* will subsist: it will take time, while the sterilizing effect of *Verdunisation* is instantaneous.

But we are not discussing the chemical methods by which certain artificially composed waters or solutions may either defy all quantities of chlorine much above their chlorine-demand and remain septic or on the contrary be sterilized with very minute quantities of chlorine, below their chlorine-demand without agitation.

This is certainly what was the object of the article by Nachtigall and Ali and through which they hoped to establish that *Verdunisation* can only succeed in *certain waters*.

We have seen that the falsity of the need of *certain waters* is shown by the enormous number of applications of "*Verdunisation*" in all the countries where the "*axiom*" is not preserved by its servants as a holy and sacred revelation of which nobody can doubt without committing a heresy in scientific creed.

Their conclusions are that:

(1) The velocity of chlorine-absorption by the water is playing the main part in the disinfection of the water.

(2) This velocity can be determined by certain reagents.

(3) According to their types many waters and solutions cannot be sterilized with a chlorine quantity much greater than their chlorine-demand whereas others can be sterilized with a chlorine quantity corresponding to only a fraction of their chlorine-demand.

These conclusions are obtained by experiments on solution containing gelatin or albumin or grape sugar.

In the first case (gelatine solution), any quantity of chlorine is unable to destroy bacteria and the residue of chlorine after five minutes is very small, 0.5 p.p.m., even if you put 4 times the quantity of chlorine which the water demands.

In the second case (albumin solution), there remain still 3,000 bacteria per liter with the chlorine-demand, but it disappears with twice the chlorine-demand giving a residual of 0.05 p.p.m. after 5 minutes.

In the third case (sugar solution), the bacteria disappear with five-sixths of the chlorine-demand.

These interesting results are obtained with solutions which do not deserve to be called: "water" but only solutions.

Their interpretation by the authors that in ordinary chlorination the shortest time chlorine disappears the greatest quantity of that body must be used for disinfection, and that if chlorine is absorbed very slowly a quantity inferior to the chlorine-demand is sufficient.

The consequences of these experiments unfortunately concern exclusively the process of chlorination devoid of agitation the rules of which the authors dubbed the "AXIOM."

If they had tried to follow the principles of *Verdunisation* they might have been led to entirely different conclusions.

I do not pretend to prophesize what *Verdunisation* would have done with solutions of gelatin, albumin or sugar such as they used.

But the authors would certainly not have identified the results of *Verdunisation* which are *instantaneous*, with the results of the treatment of solutions where the chlorine-absorption is the slowest.

In fact the study of Nachtigall and Ali refers explicitly to chlorination without agitation and they made a grave error in trying to explain by their experiments the phenomenon of *Verdunisation* based essentially on an agitation, which causes an instantaneous chlorine-absorption, with a phenomenon based precisely on the contrary, that is, on the slowness of chlorine-absorption.

I wish to thank Nachtigall and Ali for the frank and straightforward exposition at the beginning of their article of the usual method the rules of which they called an "axiom" and the *method of Bunau-Varilla* which I call the *Verdunisation*.

This latter method obtains exactly the same sanitary results as the application of the rules expressed by the "axiom" but the simplification is astounding:

- (1) No laboratory is required.
- (2) No second treatment is required.
- (3) The chlorine dose is invariable and so small that it is inexpensive.
- (4) No bad taste is generated in the water, except if it contains phenol in which case ammonia should be added.
- (5) The sterilizing action is instantaneous: a dangerous water before passage through the pump is perfectly good after that passage.

In a word, the delicate and complicated sanitation of the water by the rules of the "AXIOM" which requires the constant scientific atten-

tion of an expert is reduced by the "Verdunisation" to an operation just as simple as the salting of a broth by a cook.

Its efficacy, its innocuousness, its cheapness, and its simplicity are wonderful.

Unfortunately it meets the desperate opposition of the experts which see in a method provided with such qualities a reproach to them for having so long recommended the complicated rules expressed by the "axiom."

May I add that having discovered that system during the war, on the bloody battlefield of Verdun, I refused to take any patent or to receive any remuneration for the applications of the Verdunisation. It is free for all in France as outside of France.

PHILIPPE BUNAU-VARILLA.<sup>1</sup>

<sup>1</sup> Paris, France.

## ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

**Key:** American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

**Chemical Embrittlement of Boilers.** W. W. ROBINSON, Jr. Petroleum World, 28: 2; 63-7, 89, 91-3, 1931. From Chem. Abst., 25: 3419, July 10, 1931. Series of Southern California boiler-water concentrates was subjected to analysis for total solids, sodium hydroxide, sodium carbonate, sodium sulfate, and pH, for purpose of investigating conditions attending embrittlement of boiler steel by action of sodium hydroxide. Limiting value for safe operation set by PARR and STRAUB for ratio, sodium sulfate to total alkalinity as sodium carbonate (cf. C. A., 20: 2814), was found to be much too high. By calculating the ratio  $(\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CO}_3)/\text{NaOH}$ , that is, by recognizing sodium carbonate as well as sodium sulfate as an inhibitor of embrittlement by caustic, results more in accordance with fact that there had been no boiler failures with waters in use were obtained. When concentration of sodium hydroxide in water builds up to certain level, carbon dioxide is reabsorbed and sodium carbonate regenerated at expense of sodium hydroxide. Hence it would be possible in some cases to control the ratio by allowing high total solids to accumulate in water.—R. E. Thompson.

**Sea Water at the Puget Sound Biological Station from September, 1928, to September, 1929.** THOMAS G. THOMPSON and MARTIN W. JOHNSON. Pub. Puget Sound Biol. Sta., 7: 345-68, 1930; cf. C. A., 24: 1445. From Chem. Abst., 25: 3530, July 20, 1931. Data collected during year are tabulated and compared with information obtained in previous years. Accurate results for silicates and phosphates can be obtained only by very prompt examination of samples.—R. E. Thompson.

**Microdetermination of Silver in Oligodynamic Water.** C. Egg. Schweiz. med. Wochschr., 59: 84-6, 1929. From Chem. Abst., 25: 3590, July 20, 1931. The silver is removed electrolytically from an alkaline bath after suitable concentration of sample, and is finally determined volumetrically with 0.001 normal iodide solution.—R. E. Thompson.

**Simplified Apparatus for the Determination of Carbon Dioxide. Application to the Determination of Carbon Dioxide in Sea Water and of Carbonates in Soils.** M. NICLOUX. Compt. rend. soc. biol., 101: 182-6, 1929. From Chem. Abst., 25: 3593, July 20, 1931 (cf. C. A., 21: 3857).—R. E. Thompson.

**Further Experience of the Bismuth Sulfit Media in the Isolation of *E. Typhi* and *S. Schotmülleri* from Feces, Sewage, and Water.** W. JAMES WILSON and E. M. McV. BLAIR. *J. Hyg.*, 31: 138-61, 1931. From *Chem. Abst.*, 25: 3685, July 20, 1931. New standard bismuth medium was prepared as follows: to 100 cc. hot 3 percent nutrient agar is added 2.5 cc. 20 percent solution of glucose; 7 cc. of previously boiled mixture consisting of 100 cc. 20 percent solution of sodium sulfite (anhydrous), 50 cc. liq. bismuthii, 10.5 grams sodium phosphate (exsiccated), and 0.5 cc. 1 percent solution of brilliant green. Medium is rendered more selective for *E. typhi* by addition of 4 or 5 cc. absolute alcohol: substitution of 2 cc. propyl alcohol makes medium more selective for para B. Bacto, or Fairchild's, peptone, not Witte's, should be used.—R. E. Thompson.

**The Determination of Calcium, Magnesium, Nitrate and Sulfate Contents of Drinking Water by Electrical Conductivity Measurements.** F. SARTORIUS. *Gesundh.-Ing.*, 54: 36-8, 1931. From *Chem. Abst.*, 25: 3747, July 20, 1931. Titration curves are given.—R. E. Thompson.

**The Purification of Water by Use of Activated Charcoal.** O. KOENIG. *Gesundh.-Ing.*, 54: 273-8, 294-7, 1931; cf. *C. A.*, 24: 905. From *Chem. Abst.*, 25: 3747, July 20, 1931.—R. E. Thompson.

**The Liquor Effluents from the Gas and Coking Industries.** ALLAN C. MONKHOUSE. *Trans. 2nd World Power Conf.*, Berlin, 2: 75-89, 1930; cf. *C. A.*, 25: 2547. From *Chem. Abst.*, 25: 3751, July 20, 1931. Chief constituents of liquor effluents from carbonization industry are phenols, cresols, xylenols, higher tar acids (catechol), thiocyanate, thiosulfate, ferrocyanide, pyridine, naphthalene, etc. Volume of liquor depends on nature of coal, on its moisture content, and on methods of carbonization and ammonia recovery. Analyses of effluent liquors are given.—R. E. Thompson.

**A Test for the Ferrous Ion.** LÁSZLO EKKERT. *Magyar Gyógyszéresztud. Társaság Értesítője* 7: 231-2, 1931. From *Chem. Abst.*, 25: 3931, August 10, 1931. As little as 0.001 milligram of iron can be detected by means of dimethylglyoxime, which gives deep red coloration with ferrous ion. Test can be obtained with lactate, or oxalate, of iron.—R. E. Thompson.

**Possible Rôle of Microorganisms in the Precipitation of Calcium Carbonate in Tropical Seas.** WERNER BAVENDAMM. *Science* 73: 597-8, 1931; *Ber. deut. botan. Ges.*, 49: 282-7. From *Chem. Abst.*, 25: 4020, August 10, 1931.—R. E. Thompson.

**A Study of the Corrosion of the Corbeau (Concrete) Tunnel.** G. BATTÀ. *Chimie & industrie*, Special No., 548-54, March, 1931. From *Chem. Abst.*, 25: 3799, July 20, 1931. Tunnel was rapidly attacked by infiltration of magnesium-sulfate-bearing waters from coal seams. From comparison of composition of sound, with that of deteriorated, cement and of water before, with that after, infiltration through concrete, author concluded that corrosion took place

differently from in sea water, or gypsum-bearing water. Fundamental phenomenon, in addition to formation of CANDLOT's salt ( $3\text{CaSO}_4 \cdot \text{Al}_2\text{O}_3 \cdot 3\text{CaO} \cdot 3\text{OH}_2\text{O}$ ), consisted in relatively rapid crystallization of considerable quantity of calcium sulfate in concrete, together with decrease in lime content.—*R. E. Thompson.*

**Rapid Method for the Determination of Organic Matter in Water.** P. GARCIA NOVOA. *Voz. Farm.*, 1: 6-9, 1930; *Chimie & industrie*, 25: 1114, 1931. From *Chem. Abst.*, 25: 4073, August 10, 1931. Prepare 10-cc. color standards containing 0.01 to 0.1 cc. of freshly prepared permanganate solution (0.01 gram in 10 cc.). To 10 cc. of sample add 0.1 cc. of the permanganate solution and 1 or 2 drops of sulfuric acid; boil and, if completely decolorized, add another 0.1 cc. of permanganate and boil again, repeating until solution is not completely decolorized, and compare with standards. Each 0.01 cc. permanganate consumed is equivalent to 0.5 p.p.m. of organic matter. Necessity of rinsing glassware with sulfuric acid solution of permanganate is emphasized.—*R. E. Thompson.*

**Investigations on Clay Suspensions.** RENÉ DUBRISAY. *Chimie & industrie*, Special No., 579-86, March, 1931; cf. *C. A.*, 23: 1234, 5081; 24, 3413. From *Chem. Abst.*, 25: 3900, August 10, 1931. Stability of clay suspensions in water is affected by addition of acids or alkalies, maximum stability being obtained in weakly alkaline solutions, of definite pH for given clay, but varying with different clays. Acid, or strongly alkaline solutions produce flocculation. This was confirmed both by measuring rate of sedimentation and by nephelometric determinations. To explain above phenomena, it is suggested that, in contact with water, clay particles form complex  $\text{AH}_2\text{O}$  which behaves as weak acid and is dissociated according to:  $\text{AH}_2\text{O} \rightleftharpoons \text{AO}^- + 2\text{H}^+$ ; results of conductivity measurements are offered in support of this theory. In presence of buffers (e.g., KOLTHOFF's carbonate or SÖRENSEN's phosphate buffer solutions) at, or near, the pH of maximum stability, deflocculation occurs. In presence of flocculating agents, supernatant liquid is optically void under ultramicroscope after few hours, but in presence of ammonium hydroxide, suspended particles, visible through ultramicroscope, remain after standing 2 weeks. Characteristic iridescence produced on stirring weakly alkaline clay suspensions (which is not produced in acid, or in strongly alkaline, solutions) is explained by fact that particles have lamellar form and place themselves tangentially to vortex lines created by agitation, while in acid, or strongly alkaline, solutions, the particles are agglomerated. Lamellar structure of even the finest particles can be observed under ultramicroscope. Volume of deposit formed from clay suspension decreases with increasing pH, reaches minimum, and then increases again, variations in volume being attributed to amount of water interposed between particles of sediment. There are two possible explanations of this phenomenon. (1) In weakly alkaline medium, ultramicroscopic particles possessing Brownian movement may remain in suspension and exercise an osmotic pressure (too small to be measured or detected by any known method) which tends to compress the deposit. (2) Finer particles can settle closer together than coarser ones, particularly as,

in case of clay suspensions, fine particles are lamellar in form, while coarser ones are produced by indiscriminate agglomeration of fine lamellae. Both explanations are probably involved in phenomenon. X-ray spectrograms of deposits and of dry clay prepared by DEBYE and SCHERRER's method showed that in every case particles have same crystalline structure; this indicates that there is no chemical combination of alkali with clay, though there may be a thin layer of adsorbed alkali invisible under x-rays. In deposits formed in weakly alkaline solution, however, the interference rings are much less sharp; this is due to reduction in size of particles.—*R. E. Thompson.*

**The Oxidation Velocity of Sodium Sulfite and the Velocity of Solution of Oxygen in Water.** SUSUMU MIYAMOTO, TETSUO KAYA and AKIRA NAKATA. *J. Sci. Hiroshima Univ., Ser. A*, 1: 2, 125-45, 1931; cf. *C. A.*, 24: 5575. From *Chem. Abst.*, 25: 3907, August 10, 1931.—*R. E. Thompson.*

**Use of Acridine Dyestuffs for the Determination of Nitrites.** W. M. RUBEL. *Z. Untersuch. Lebensm.*, 60: 588-92, 1930. From *Chem. Abst.*, 25: 3928, August 10, 1931. Rivanol (Koremann), 2-ethoxy-6, 9-diaminoacridine hydrochloride, is a yellow-green antiseptic, which has solubility of 1:260 and is fairly stable in dark. If 0.5 cc. of 0.1 percent solution and 0.5 cc. hydrochloric acid (density 1.06) are added to 10 cc. of 2- to 100-fold dilution of liquid to be tested, a yellow-green to orange or red color is obtained, depending on amount of nitrite present. This can be matched against standards containing known amounts of sodium nitrite and treated in same manner, final comparison being made in Duboscq colorimeter. Color, which results from diazotization of amino group, changes to yellow on heating, and is stable in light for 1 hour, when brown precipitate appears, but for longer in dark. Sensitiveness, 0.001 milligram in 10 cc., is greater than that of *m*-phenylenediamine reaction, and equal to that of GRIESS reaction, but color is more stable than that of latter and, unlike it, is unaffected by phenol, or ammonium salts, and is only slightly suppressed by thymol. Less than 10 percent of sodium chloride, or of nitrate, has no effect; free iodine produces green-blue color. Free ammonia, which interferes with color by alteration of pH, must be neutralized.—*R. E. Thompson.*

**Dissolved Phosphorus and Inorganic Nitrogen in the Water of the Mississippi River.** A. H. WIEBE. *Science*, 73: 652, 1931; cf. *C. A.*, 16: 1927. From *Chem. Abst.*, 25: 4332, August 20, 1931.—*R. E. Thompson.*

**Pipe-Line Currents and Soil Resistivity as Indicators of Local Corrosive Soil Areas.** E. R. SHEPARD. *Bur. Standards J. Research*, 6: 683-708, 1931. From *Chem. Abst.*, 25: 3948, August 10, 1931. Present tendency in protection of pipe lines is away from uniform coating for entire length of line and toward selection of coatings with respect to protection of particularly corrosive areas, so-called "hot spots." Location of such areas is of great importance, with respect both to selection of coatings for new lines and to the reconditioning of old ones. Extensive investigation of 12 pipe lines, from Gulf coast to southern Kansas, revealed an apparent correlation between line currents, soil resistivity, and corrosion. Galvanic currents of measurable strength were

found on all lines examined. As a rule, pipes were found to collect current in areas of normal and high resistivity and to lose current in areas of low resistivity. Many cases of abrupt loss, or discharge, of current occurred in soils of unusually low resistivity. In such areas pipes were badly corroded. Although no direct relation was found between resistivity of soils and their corrosiveness, abrupt changes in resistivity and unusually low values were found to be significant with respect to corrosion. Soils having resistivity of about 500 ohms, or less, were invariably found to be highly corrosive. A better relationship between resistivity and corrosiveness exists in alkaline than in acid soils. Technique of surveying pipe lines for galvanic currents is discussed, and apparatus for simply and quickly measuring soil resistivity is described.—*R. E. Thompson.*

**Experiences in Chlorinating Condenser Circulating Water.** VINCENT M. FROST and W. F. RIPPE. *Fuels and Steam Power (A. S. M. E. Trans.)* 53: 8, 131-8, 1931. From *Chem. Abst.*, 25: 4335, August 20, 1931. Chlorination of condenser water at Kearney Station in New Jersey resulted in increased vacuum in system and eliminated rubber-plug cleaning of condensers. It also eliminated boiling of condensers. Prior to chlorination it was necessary to clean condensers once a week in warm weather. Trouble was due in part to organic matter, algae, etc. Maximum residual chlorine at condenser inlet was 0.3 p.p.m. There was no sign of corrosion after one year's use of chlorine.—*R. E. Thompson.*

**The Application of the Decarbonation Method of E. Jalowetz for Determining the Composition of Water.** MAX HAMBURG. *Brau- u. Malzind.*, 31: 48-50, 1931. From *Chem. Abst.*, 25: 4073, August 10, 1931. Method is described for determination of anions and cations in water, and their combination to form salts. Usual water analysis is first carried out, then water is decarbonated in apparatus consisting of steam pot and small autoclave, furnished with exhaust and safety valves and manometers. A steam pipe, with valve in center, connects steam apparatus with autoclave and ends deep in latter with nosepiece of fine holes. Half a liter of sample is placed in autoclave, and steam pot is filled with 2 liters of distilled water and heated to pressure of 10 atmospheres. The steam, after air has been expelled, is directed from pot into autoclave, pressure being regulated to 5 atmospheres and held at that for 5 minutes. After cooling, sulfate, lime, magnesia, and carbon dioxide contents of decarbonated water are determined. Since sulfate content does not change, its determination serves only to obtain dilution of original water. As calcium carbonate is practically completely precipitated, carbon dioxide found is calculated with part of magnesia, remaining magnesia with sulfate, and any remaining sulfate with lime. Values found for lime and magnesia in decarbonated water are deducted from those found in original water, and remainders calculated with carbon dioxide as calcium and magnesium carbonates. Example of typical analysis is given for illustration of method.—*R. E. Thompson.*

**Use of Membrane Filters in Sterile Filtration.** B. SCHWENKE. *Pharm. Ztg.*, 76: 682, 1931. From *Chem. Abst.*, 25: 4151, August 20, 1931. Use of

certain membrane filters, having pores 0.75 to 1.0 $\mu$  in diameter and yielding perfectly sterile filtrates, is discussed.—*R. E. Thompson.*

**Electric Determination of Water Purity.** G. F. TAGG. Engineer, 151: 532-4, 1931. From Chem. Abst., 25: 4073, August 10, 1931. Various commercial types of apparatus for determining conductivity of water are described.—*R. E. Thompson.*

**Alkalization of Boiler Feed Water with Soda.** J. F. BOGTSTRA. Arch. Suikerind., 38: 1003-5, 1930; Sugar Abstracts in Facts About Sugar, 26: 132. From Chem. Abst., 25: 4074, August 10, 1931. Opinion has been expressed lately that addition of sodium carbonate to boiler feed water is harmful, for under high pressure and temperature it is hydrolyzed to sodium hydroxide and carbon dioxide, both of which are said to attack walls of boiler. Numerous analyses of condensates from first and second effects have shown that amount of carbon dioxide never exceeded 25 p.p.m., whereas amount allowed by rules of association of boiler owners (a German mutual boiler insurance concern) is 35 p.p.m. When soda is uniformly fed to boiler feed water there is no danger of exceeding this limit, but for safety it is advisable to use sodium hydroxide instead of carbonate. Safest concentration is about 400 p.p.m.—*R. E. Thompson.*

**Electrolytic Production of Sodium Hypochlorite at the Petrograd Water Plant.** N. A. PUSHIN and M. G. KAUKHCHEV. Bull. soc. chim. roy. Yougoslav., 1: 2, 47-67. From Chem. Abst., 25: 4185, August 20, 1931. Daily capacity of plant is 600 kilograms of active chlorine. The KELLNER cell is used. Electrodes of ACHESON graphite were substituted for platinum electrodes. About 0.05 percent of mixture of 66 percent ground pitch, 33 percent crystalline soda, 0.75 percent calcium chloride, and 0.25 percent sodium hydroxide is added. Impurities in brine used are controlled to keep sulfates below 10 percent, magnesium salts below 0.05 percent, and insoluble substances below 0.5 percent. Average of 17.3 grams active chlorine per liter is obtained; 6.15 kilowatt hours and 6.22 kilograms sodium chloride per kilogram active chlorine are used.—*R. E. Thompson.*

**New Test for Fluorides.** B. KOONE. Chemist-Analyst, 20: 4, 14-5, 1931. From Chem. Abst., 25: 4201, August 20, 1931. Test depends upon color change which colloidal aqueous solution of red zirconium alizarin lake undergoes by contact with fluorine (cf. STONE, C. A., 25: 1181).—*R. E. Thompson.*

**Newest Methods for the Determination of Small Quantities of Iodine.** VIKTOR KURELEC. Magyar Chem. Folyóirat, 37: 93-103, 1931. From Chem. Abst., 25: 4197, August 20, 1931. Methods of (1) FELLEBERG, (2) PFEIFFER, and (3) SCHWABOLD were examined. Exact results may be obtained with any of these methods after some practice. Method (3) is most rapid, and method (1) requires most time. Method (1) is suggested for serial work, especially when analyzing materials with very small iodine content. Method (2) is adapted for analysis of liquids, since the tedious preliminary evaporation

to dryness can thus be eliminated. Method (3) uses only 1 or 2 grams of substance; it can, therefore, be applied to analysis of small quantities with high iodine content.—*R. E. Thompson.*

**Microchemical Determination of Copper with Salicylaldoxime.** WILHELM REIF. *Mikrochemie (N. S.)*, 3: 424-9, 1931. From *Chem. Abst.*, 25: 4197, August 20, 1931. Ammonium acetate as ordinarily obtained on market contains 1 molecule ammonium acetate and 1 molecule acetic acid; it can be used, therefore, for neutralizing an ammoniacal solution. To from 2 to 5 cc. copper solution containing from 0.4 to 3.5 mg. copper add ammonium hydroxide carefully until blue color develops. Decolorize with ammonium acetate solution and then, to precipitate copper, add freshly prepared 5 percent solution of salicylaldoxime in alcohol. Filter, wash with water and then with alcohol, dry at 105° and weigh. Precipitate contains 18.95 per cent copper. If iron is present it is necessary to add a little tartaric acid at the start. Results cited are excellent.—*R. E. Thompson.*

**A New Method for the Determination of Hypochlorite Bleaching Agents.** A. JOUNIAUX. *Monde ind.*, 57: 835-7, 1930; *Chimie & industrie*, 25: 1086, 1931. From *Chem. Abst.*, 25: 4200, August 20, 1931. After criticism of known methods, following is recommended as being rapid and accurate. To hypochlorite solution add excess of standard arsenious acid solution (4.488 grams per liter), stir, let stand few minutes, acidify strongly with hydrochloric acid, and titrate excess arsenious acid with standard potassium bromate (2.525 gram per liter) in presence of methyl orange. End of reaction is marked by decolorization of solution.—*R. E. Thompson.*

**New Colorimetric Determination of Ammonia.** KONSTANTIN G. MAKRISS. *Z. anal. Chem.*, 84: 241-2, 1931; cf. *C. A.*, 24: 4731, 1930. From *Chem. Abst.*, 25: 4200, August 20, 1931. Details are given for using 2 drops of 5 percent tannin solution and 1 drop of 20 percent silver nitrate solution for colorimetric determination of very small amounts of ammonia. Claimed that test is more sensitive than usual NESSLER test and equally convenient.—*R. E. Thompson.*

**Iron Bacteria in Manchurian Soil and a Water Pipe.** KAZUE TSUKUNAGA. *J. Sci. Agr. Soc. (Japan)*, 327, 79-91, 1931. From *Chem. Abst.*, 25: 4298, August 20, 1931. *Leptothrix ochracea* Kütz and *Siderocapsa major* Mol. were found in Manchurian soil and, together with *Crenothrix polyspora* Cohn and *Gallionella ferruginea* Chol., were found in water pipe at Kuochiatien, Manchuria. Greater part of deposits in water pipe consists of manganese compounds (53 percent manganese dioxide).—*R. E. Thompson.*

**A New Iron Bacterium, *Siderocapsa coronata* Redinger.** KARL REDINGER. *Arch. Hydrobiol.*, 22: 410-4, 1931. From *Chem. Abst.*, 25: 4298. August 20, 1931. An iron bacterium found in lake near Lunz is surrounded by gelatinous capsule which contains iron and manganese.—*R. E. Thompson.*

**Water Supply of Manila from Underground Sources.** LEOPOLDO A. FAUSTINO. *Philippine J. Sci.*, 45: 119-49, 1931. From *Chem. Abst.*, 25: 4332, August 20, 1931.—*R. E. Thompson.*

**Artesian-Well Waters in Manila and Neighboring Municipalities.** R. H. AGUILAR and LOURDES OCAMPO. *Philippine J. Sci.*, 45: 151-79, 1931. From *Chem. Abst.*, 25: 4332, August 20, 1931. Extensive study of these waters, with analytical data, in both ionic and combined forms. Sodium and bicarbonate radicals are predominant constituents. Hardness is usually below 230 p.p.m. The few highly mineralized waters are located in Manila and Pasay, south of Pasig River. Pasay is characterized by moderately hard underground waters. Sodium bicarbonate is present in 72.5 percent of the waters in concentrations higher than minimum therapeutic dose, but these waters are considered by residents as acceptable for drinking purposes.—*R. E. Thompson.*

**Bacteriological Survey of Artesian Wells in Manila and Vicinity.** OTTO SCHÖBL and T. V. ROSARIO-RAMIREZ. *Philippine J. Sci.*, 45: 201-10, 1931. From *Chem. Abst.*, 25: 4332, August 20, 1931. In general, water from artesian wells in Manila and vicinity meets requirements for drinking waters, that is, that untreated waters must not contain more than 500 colonies per cc. and that test for *B. coli* must be negative, and treated waters, not more than 100 colonies and test for *B. coli* negative. When wells show contamination, examination of mechanical parts, proper protection of surroundings, and thorough disinfection will assure further usefulness. Test for vibrios serves as additional very sensitive method for detection of fecal pollution in countries in which cholera is endemic. Results of bacteriological examinations are given.—*R. E. Thompson.*

**Relative Radioactivity of Deep-Well Waters in Manila and Vicinity.** R. H. AGUILAR. *Philippine J. Sci.*, 45: 183-97, 1931. From *Chem. Abst.*, 25: 4332, August 20, 1931. Rn contents of different well waters are tabulated. No abnormal quantities were found. Quantity of Rn seems to bear no general relation to physical and chemical qualities. As has been found true of large proportion of natural waters elsewhere, Rn content of these waters is far below minimum considered necessary to have therapeutic effect, i.e., between 20 and 500 millimicrocuries per liter.—*R. E. Thompson.*

**The Theory of Lake Types.** D. LASTOČKIN. *Arch. Hydrobiol.*, 22: 546-79, 1931. From *Chem. Abst.*, 25: 4331, August 20, 1931. Three fundamental types of lakes, oligo-meso-, and eu-trophic, can be distinguished on basis of chemical and biological characteristics —*R. E. Thompson.*

**Chemistry of Some Humic Lakes.** GEORGE LÖNNERBLAD. *Arch. Hydrobiol.*, 22: 355-68, 1931. From *Chem. Abst.*, 25: 4331, August 20, 1931. Electrolyte stratification in water of certain Swedish lakes, as determined by conductivity measurements, is mainly influenced by physical rather than chemical factors. The pH of surface water in summer varies between 6.6 and 6.8, but is

considerably lower in winter. Daily variations are detectable to depth of 4 meters. Maximum difference between surface and bottom water is 0.3 pH. Inflowing brook water has lower pH than lake, and isolated surface pools have pH of from 4.0 to 4.2.—*R. E. Thompson.*

**Feforvatn: a Physiographic and Biological Study of a Mountain Lake.** KAARE M. STROM. *Arch. Hydrobiol.*, 22: 491-536, 1931. From Chem. Abst., 25: 4331, August 20, 1931. Lake is in province of Opland, Norway. Consideration of oxygen deficiencies in lakes emphasizes individual behavior of each lake. Variation in oxygen content with depth shows minimum deficiency at the metalimnion at 15 meters. pH decreases and conductivity increases with depth. Water is extremely clear. Distribution of plankton is given. Comparison with other Norwegian lakes concludes the paper.—*R. E. Thompson.*

**The Occurrence of a Pronounced Oxygen Minimum in the Metalimnion of Lake Sakrower near Potsdam.** C. S. ANTONESCU. *Arch. Hydrobiol.*, 22: 580-96, 1931. From Chem. Abst., 25: 4331, August 20, 1931. During summer stagnation, very pronounced minimum in oxygen content of this lake occurs at depth at which temperature change with depth is most rapid (metalimnion). This may be dependent on accumulation of organisms at this level, which is probably the least disturbed by water movements.—*R. E. Thompson.*

**Purification of Water by Electroösmose.** EDWARD BARTOW and R. H. JEBENS. *Proc. Iowa Acad. Sci.*, 37: 211-6, 1930; cf. *C. A.*, 24: 5397. From Chem. Abst., 25: 4332, August 20, 1931. Cathode water cannot be mixed with tap water for feed water without first treating tap water by either lime-soda or lime-barium method. Advantages claimed by Elektro-Osmose, A. G., were all substantiated but one. Time and energy are lost in starting, as water is not of desired quality until machine has been in operation 1 hour. Cathode water could be used industrially in any process where lime water is used, and anode water as bleaching and disinfecting wash water. Less than one-half as much electrical energy would reduce residue from 600 to 300 p.p.m., as would be required to complete reduction from 300 p.p.m. to zero.—*R. E. Thompson.*

**Water Purification Plant of the City of Tampico.** PAFNUNCIO L. PADILLA. *Ingenieria (Mexico)* 6: 138-40, 1931. From Chem. Abst., 25: 4333, August 20, 1931. Water supply of Tampico, Mexico, is treated with alum, prechlorinated (which reduces bacteria 85 percent), settled, passed through rapid sand filters, and again chlorinated. Daily capacity of plant is 17 million liters. Chlorine used totals 0.6 kilogram and alum, 17.1 to 34.2 kilograms per 1000 liters of raw water.—*R. E. Thompson.*

**Recent Advances in the Preparation and Reactivation of Active Charcoal.** FRANZ KRCZIL. *Kolloid-Z.*, 55: 366-71, 1931. From Chem. Abst., 25: 4363, August 20, 1931.—*R. E. Thompson.*

**Methods of Bacterial Counts in Water.** L. N. GURFEIN. *Ark. biol. Nauk*, 30: 529-47 (in French 548), 1930. From Chem. Abst., 25: 4334, August 20,

1931. Comparative study of usual methods leads to following conclusions. (1) In beef infusion-peptone agar plate method not more than 50 percent of the organisms develop into colonies. (2) In precipitation methods, the salts of iron, aluminum, etc., used have inhibiting effect upon subsequent growth of bacteria after seeding of sediments. (3) Direct counting of stained organisms in such sediments gives low results because of incomplete sedimentation. (4) Direct count of suspensions stained with 10 percent erythrosin ("extra") in 5 percent phenol proved to be most accurate. (5) Addition of 0.8 percent sodium chloride produces more homogeneous distribution of organisms in samples during staining. (6) To prevent growth of organisms during analytical manipulations, samples in test tubes are heated in boiling water bath for 20 minutes. (7) Autoclaving and addition of preservatives (chloroform and formaldehyde) cause agglutination and hinder counting. (8) In this method, counting 20 fields under microscope out of area of 1 square centimeter, mean error does not exceed 1.5 percent.—*R. E. Thompson.*

**A Simple Automatic Pressure Regulator for Filtration.** EINAR LEIFSON. *Science*, 73: 707-9, 1931. From *Chem. Abst.*, 25: 4445, September 10, 1931. Directions are given for making regulator which will hold a filter under any desired pressure for any length of time.—*R. E. Thompson.*

**Specification of Fuel Used for Diesel Engines.** TETSURO SUWA. *Trans. 2nd World Power Conf. (Berlin)*, 18, 289-99, 1930. From *Chem. Abst.*, 25: 4391, August 20, 1931. After discussing influence of each quality of Diesel oil upon functioning of engine, it is concluded that viscosity, ash, free carbon, water content, and calorific value are essential qualities to be included in all specifications. Specific gravity and ultimate analysis should be given for information, and flash point and distillation test can be neglected. The auto-ignition temperature (A.I.T.) is most important for differentiating fuels, especially oils of non-petroleum origin. Suitable apparatus for its determination is described and results given for number of oils. Diesel-oil specifications should be in two classes: (1) heavy oil, shale-oil distillate, and low-temperature-tar neutral oil and (2) coal-tar oil and other crude fuels. For (1) the following specifications are suggested: viscosity (Redwood), completely liquid at 15°, < 200 seconds at 30°, < 80 seconds at 50°; ash, < 0.05 percent; free carbon, < 0.1 percent; water, < 1 percent; calorific value, > 9000 calories kilogram; and A.I.T., < 300°.—*R. E. Thompson.*

**Boric Acid in Chokrak Salt Lake.** V. I. NIKOLAEV and S. K. KOSMAN. *Compt. rend. acad. sci. U. R. S. S.*, 1930 A, 485-8. From *Chem. Abst.*, 25: 4492, September 10, 1931. Methods used for analysis of lake samples and for determination of boric acid in brine and mud are described. Direct titrations of boric acid in solution with standard base in presence of glycerol were made with phenolphthalein as indicator; end point was disappearance of red color on back titration with hydrochloric acid. On evaporation of concentrated brine, boric acid content remained almost constant, probably as result of precipitation as magnesium metaborate with other salts.  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  changes to  $\text{Na}_2\text{B}_6\text{O}_{11} \cdot 5\text{H}_2\text{O}$  when brine is cooled to 25°.—*R. E. Thompson.*

**The Discovery of a New Spring Containing Iodine and Sulfur in Wiessee am Tegernsee, Bavaria.** D. ALBRECHT. *Kali*, 25: 161-4, 1931. From Chem. Abst., 25, 4639, September 10, 1931. While drilling for oil was progressing, a radio-active spring of high iodine and sulfur content was discovered at depth between 600 and 700 meters. One kilogram of water contains 34 milligrams iodine. This is highest iodine content of any spring in Germany.—R. E. Thompson.

**The Bacteriological Examination of Drinking Water.** JAN SMIT. *Nederland. Tijdschr. Hyg. Microbiol. Serol.*, 6: 19-39, 1931. From Chem. Abst., 25: 4639, September 10, 1931. Bacteriological examination of drinking water, during recent years, has become increasingly complicated on account of constantly growing differentiation of colon group of bacteria. Author suggests coli examination, laying stress on fermentations caused by water, instead of detailed examination of inconstant properties of coli bacteria that can be isolated from fermenting liquors. Comparisons of ELJKMAN results with those of fermentation in liquids containing glucose and lactose are of great help.—R. E. Thompson.

**The Purification of Waste Waters by Coagulants.** S. A. VOZNESENSKII. *Trans. Central Comm. Protection of Water Reservoirs*, 6: 152-64, 1927; *Chem. Zentr.*, 1930, I, 3851. From Chem. Abst., 25: 4644, September 10, 1931. Neither acids nor alkalies, except calcium and magnesium hydroxides, precipitate particles suspended in water. By addition of ferric chloride and aluminum sulfate in alkaline solution, colloidal ferric hydroxide and aluminum hydroxide are precipitated. Both precipitates are positively charged. Precipitation takes place only at certain concentrations.—R. E. Thompson.

**A Simple Practical Method for Testing Hardness of Water.** SIEGFRIED KOSCHE. *Z. ges. Textil-Ind.*, 34: 363, 1931. From Chem. Abst., 25: 4640, September 10, 1931. Rapid, practical method suitable for use in textile mills is described.—R. E. Thompson.

**Semimicrochemical Determination of Alkali Metals in Natural Waters (Bore Waters) and Silicates.** K. L. MALOROV. *Neftyanoe Khozyaistvo*, 1930, 223-5; *Chem. Zentr.*, 1930, II, 771. From Chem. Abst., 25: 4487, September 10, 1931. For determination of alkali metals in natural waters, the halides and organic substances are removed by evaporating from 2 to 10 cc. of the water with 0.5 to 2 cc. sulfuric acid. If silica is present, water is first evaporated with hydrofluoric acid and sulfuric acid is then added. Residue, which must not be heated above 350°, is precipitated with barium hydroxide to remove sulfuric acid, heavy metals, and magnesium. Alkaline earths are precipitated in filtrate with ammonium carbonate and ammonia in cold, ammonium salts removed, and residue dissolved in water and titrated with hydrochloric acid and methyl orange from microburet. Analysis may be carried out in Pyrex beakers.—R. E. Thompson.

**The Preparation of Unobjectionable Drinking Water.** FR. SARTORIUS. *Arch. Hyg.*, 105: 48-59, 1930. From *Chem. Abst.*, 25: 4639, September 10, 1931. Drinking water may be purified most satisfactorily on small scale by chlorination or ozonization. Chlorination may be accomplished by addition of either chlorine water or ampules of chloramine. Methods involving filtration through active charcoal, or through sand impregnated with silver, or use of Katadyn flasks are not satisfactory.—*R. E. Thompson.*

**Water Purification by Settling and Coagulating.** H. A. J. PIETERS and W. J. DE KOK. *Chem. Weekblad*, 28: 365-8, 1931. From *Chem. Abst.*, 25: 4639, September 10, 1931. Clarification experiments with various electrolytes showed effectiveness of calcium hydroxide, alum, and barium chloride. Addition of small amount of starch to calcium hydroxide increases its efficiency.—*R. E. Thompson.*

**Phosphate for Water Treatment in Boiler Operation.** KARL MORAWE. *Die Wärme*, 54: 412-4, 1931. From *Chem. Abst.*, 25: 4640, September 10, 1931. Use of phosphate for boiler feed water treatment is historically and theoretically discussed, and its use as an addition agent to feed water is shown to be of doubtful value.—*R. E. Thompson.*

**The Physical-Chemical Treatment of Boiler Contents.** R. STUMPER. *Die Wärme*, 54: 397-402, 1931. From *Chem. Abst.*, 25: 4640, September 10, 1931. Boiler water requirements in relation to demands are discussed. The corrective process which serves to overcome inadequacy of water purification is discussed and results of investigations of the 4 methods, (1) displacement of chemical equilibrium, (2) colloidal chemical process, (3) mechanical process, and (4) electrochemical process, are presented.—*R. E. Thompson.*

**The Evaporator and Its Application in Modern Feed-Water Superintendence.** R. KLEIN. *Die Wärme*, 54: 415-20, 1931. From *Chem. Abst.*, 25: 4640, September 10, 1931. Most common types of evaporators used in feed water preparation are discussed. Load data of evaporation surface and of vapor space from literature and from practice are compared. Evaporator may serve as deaerator and preheater besides serving as source of feed water. Special types are described.—*R. E. Thompson.*

**Intercrystalline Cracking in Steam Boilers.** F. G. STRAUB. *Trans. 2nd World Power Conf.*, Berlin, 7, 363-6, 1930; cf. *C. A.*, 25: 3607. From *Chem. Abst.*, 25: 4508, September 10, 1931. General.—*R. E. Thompson.*

**Technic of Electrometric Determination of Chlorides and Its Application to the Analysis of Sea Water.** F. VLÈS and M. GEX. *Arch. phys. biol.*, 8: No. 3-4, Suppl. 5, 1-12, 1930. See *C. A.*, 25: 2664. From *Chem. Abst.*, 25: 4489, September 10, 1931.—*R. E. Thompson.*

**Purification of Water for the Manufacture of Clear Ice.** OTTO NIEZOLDI. *Z. ges. Kälte-Ind.*, 38: 69-71, 1931. From *Chem. Abst.*, 25: 4639, September 10, 1931.—*R. E. Thompson.*

**Oxygen as a Factor in Submerged Corrosion.** EDWARD C. GROESBECK and LEO. J. WALDRON. *Proc. Am. Soc. Testing Materials (Preprint)*, 45: 1-13, 1931. From *Chem. Abst.*, 25: 4508, September 10, 1931. Tap and distilled water of controlled oxygen content and pH were circulated over specimens in apparatus made up entirely of glass and rubber. The pH was controlled by introducing carbon dioxide for lower pH and by adding trace of sodium hydroxide for pH 8. Dissolved oxygen was varied from 1 to 25 cc. per liter. Open-hearth iron with 0.03 percent copper, low-carbon steel with 0.08 percent copper, copper-bearing low-carbon steel with 0.22 percent copper, and open-hearth iron with 0.43 percent copper and 0.07 percent molybdenum were studied. Corrosion increased with increasing dissolved oxygen in tap water of pH from 7.8 to 8.0. The copper-molybdenum iron was not tested in this series. With oxygen above 5 cc. per liter, the copper-bearing steel showed an advantage; but, as is the case in practice with ordinary city, brackish, and mine water, it had no appreciable advantage at lower oxygen concentrations, though corrosion was less with higher copper content. With higher oxygen, copper-bearing material was significantly superior. In distilled water with varying pH and oxygen content, corrosion rate increased with increase in oxygen at pH from 5 to 6; that pH of 4.5, 7, and 8, it increased to maximum with increase in oxygen and then decreased, apparently because of passivating action. Materials with 0.22 and 0.43 percent copper showed lower corrosion rates than those with less copper.—*R. E. Thompson.*

**A Hardness-Regulator Equivalence for Lime-Soda Plants and Decarbonating Plants.** EUGEN HAAS. *Die Wärme*, 54: 427-8, 1931. From *Chem. Abst.*, 25: 4640, September 10, 1931. Important innovation in feed water treatment is described with automatic regulation of lime water flow to obtain desired hardness. Apparatus operates on basis of analysis of raw or of pure water and may be used for addition of other chemicals. Theory of design is presented.—*R. E. Thompson.*

**The Corrosion of Power Plant Equipment by Flue Gases.** HENRY F. JOHNSTONE. *Univ. Ill. Eng. Expt. Sta., Bull.* 228: 1-122, 1931. From *Chem. Abst.*, 25: 4509, September 10, 1931. Investigation, in cooperative agreement with Utilities Research Commission of Chicago, of corrosion problems arising in power plant operation from trend toward lower stack-gas temperatures and from use of lower grades of coal with higher percentages of ash and sulfur. Report covers (1) survey of plants to observe conditions favorable to corrosion; (2) chemical reactions in boiler furnace in their relation to corrosion and slag formation; (3) description of laboratory experimental work on corrosion; (4) results of tests on various corrosion-resisting alloys and on protective coatings under flue conditions; (5) description of new methods for determining dew point and sulfur dioxide and trioxide concentrations in flue gas; (6) discussion of fundamental corrosion reactions. Summary of plant data indicates that corrosion occurs in stoker-fired plants when coal sulfur exceeds 2 percent, but that little trouble is experienced in pulverized-fuel systems with similar coals. It is most prevalent with high-ash coals burned with high drafts which pick up large quantities of flue dust, which in turn create erosive action, and its maxi-

imum effect is produced in zone immediately in front of air intake on air preheater. Critical temperature of corrosion is about 300°F., above which any slight effect observed is similar to that taking place on ordinary boiler tubes. High concentration of moisture from steam leak or steam soot blower is especially bad and will cause corrosion with almost any kind of coal. Protective metallic coatings have not proved effective, but enameled tubes will withstand destructive action if mechanical difficulties can be eliminated. Theory of mechanics of corrosion, briefly, involves existence of hygroscopic material, especially ferric sulfate, carried by flue gases; its deposition on economizers whose temperatures are at or near dew-point of flue gases; formation of film of ferric sulfate solution on metal surface; vigorous catalytic activity of this solution in oxidizing sulfur dioxide to trioxide, which raises sulfuric acid concentration in film and so promotes corrosion activity. Oxidation of sulfur dioxide to trioxide in flue gas out of contact with film is extremely small. Proper course of action for prevention of corrosion may include choice of different fuel, change in operation or design, use of non-corroding materials for construction, or processing of fuels before burning. Specifically, by maintaining temperatures of preheater and economizer surfaces well above dew point of flue gas, in order to prevent formation of dangerous film, and by elimination of leaks in economizer, much trouble may be avoided. Series of corrosion tests of paint surfaces showed that only those of asphaltic nature with graphite and silica fillers, together with artificial resinoid types, gave promising results. Review of electrochemical theory of corrosion is appended.—*R. E. Thompson.*

**Studies on the Effect of Metals and Metal Salts on Microorganisms.** KUNIO TANAKA. *J. Biochem. (Japan)*, 13: 81-105, 1931. From *Chem. Abst.*, 25: 4574, September 10, 1931. Bactericidal and agglutinating action of metal salt on bacteria depends upon reaction of medium and is lost when acidity is greater than isoelectric point of the bacterial protein. Bactericidal action is proportional to concentration only within definite range of acidity. Loss of activity may also occur on alkaline side, but this is due to precipitation of insoluble hydroxides. Effect on bactericidal activity is apparent at lower acidity in case of more positive metal ions (zinc and lead) than of less positive (copper). Gram-positive organisms seem less sensitive to changes in acidity of medium as far as bactericidal action of metal salts is concerned.—*R. E. Thompson.*

**Microscopic Investigation of Boiler Scale.** ALICE HANTEL. *Die Wärme*, 54: 409-11, 1931. From *Chem. Abst.*, 25: 4641, September 10, 1931. The three components of boiler scale (carbonate, sulfate, and silicate) are easily detected through investigation of the double refraction of the minerals in transmitted polarized light. The preparation of thin sections for examination, and optical characteristics of minerals occurring in boiler scale are described. Photomicrographs are included.—*R. E. Thompson.*

**Practical Experiences with Boiler Scale Prevention by Trisodium Phosphate.** KOEPEL. *Die Wärme*, 54: 429-30, 1931; cf. *C. A.*, 25: 2219. From *Chem. Abst.*, 25: 4641, September 10, 1931. In spite of higher operating cost as

against soda, water-softening installation operated more economically.—*R. E. Thompson.*

**Electrical-Conductance Measurements of Water and Steam, and Applications in Steam Plants.** MAX HECHT and D. S. MCKINNEY. *Fuels and Steam Power* (A. S. M. E. Trans.), 53: 139-59, 1931. From Chem. Abst., 25: 4641, September 10, 1931. Electrical-conductance method for observing entrainment in steam and concentration of salts in steam-generating vessels is as accurate as chemical method. Correction must be made for carbon dioxide concentration. Method, of course, gives no indication of which ions are present.—*R. E. Thompson.*

**Boiler Feed Water and Boiler Scale.** GERHARD SCHMIDT. *Die Wärme*, 54: 403-8, 1931. From Chem. Abst., 25: 4640, September 10, 1931. Feed water and evaporation residues were investigated to determine chemical processes in boiler. Comparison is made between analyses of feed water and those of sludge and scale. Chemical compounds in evaporation residue indicated that lime-soda treatment was inadequate. Physical characteristics of scale depend largely on chemical composition, which is influenced by chemical reactions occurring in boiler.—*R. E. Thompson.*

**Routine Tests for the Control of Water Softening Plant.** L. O. NEWTON. *Fuel. Econ. Rev.*, 10: 59-61, 1931. From Chem. Abst., 25: 4640, September 10, 1931.—*R. E. Thompson.*

**Water Purification.** A. WICKLIEN and OTTO REGEL. *Chem. App.*, 17: 183-4, 1930. From Chem. Abst., 25: 4639, September 10, 1931. Description of mixer used in water softening with lime and soda.—*R. E. Thompson.*

**Sterilization of Potable Water by Means of Chlorine.** G. COLMET DAÛGE. *Bull. soc. encour. ind. nat.*, 130: 340-6, 1931. From Chem. Abst., 25: 4639, September 10, 1931. Drinking water may be sterilized by means of ozone, ultraviolet radiation, or by chemical procedure. Simplest and least expensive method is by chlorination with chlorine or hypochlorites. Various means of maintaining an automatic chlorine supply have been devised.—*R. E. Thompson.*

**The Supply of Caustic Soda or Soda Lye in Commerce and the Use of Soda Lye in Boiler Feed Water Superintendence.** A. GOLDBERG and ELFRIEDE RÖTTGER. *Die Wärme*, 54: 421-6, 1931. From Chem. Abst., 25: 4665, September 10, 1931. Softening reaction with sodium hydroxide is discussed. Use of soda lye for feed water treatment is described, together with calculations of amount required from analysis of raw water. Relative advantages of solid sodium hydroxide, or soda lye, are considered and apparatus for solution of the solid material is described.—*R. E. Thompson.*

**Volumetric Determination of the Sulfate Ion.** P. GRIGOR'EV and S. KOROL. *J. Chem. Ind. (Moscow)*, 7: 1004-6, 1930. From Chem. Abst., 25: 4816,

September 20, 1931. Sulfate can be titrated with divalent lead using potassium iodide as indicator, or volume of 0.1-normal barium chloride required to form barium sulfate can be determined by precipitating excess barium with definite volume of potassium bichromate in buffered solution and titrating excess iodometrically.—*R. E. Thompson.*

**Seasonal Variation of Iron and Manganese in the Water of Takasuka-Numa, Saitama.** SHINKICHI YOSHIMURA. Japan. J. Geol., 8: 269-79, 1931. From Chem. Abst., 25: 4747, September 20, 1931. Ferric oxide and manganese contents of this lake were studied at different depths up to 6 meters. Iron and manganese contents are approximately uniform at different depths during periods of recirculation, but during periods of stagnation there is marked stratification, with higher concentrations at bottom. Increase during stagnation corresponds with disappearance of dissolved oxygen. They are probably reduced from substrate by decomposition of organic matter.—*R. E. Thompson.*

**The Hydrogen-Ion Concentration of the Lake Water in Japan.** SHINKICHI YOSHIMURA. Proc. Imp. Acad. Tokyo, 7: 195-7, 1931. From Chem. Abst., 25: 4747, September 20, 1931. Discussion of pH of lake waters of Japan and of controlling factors.—*R. E. Thompson.*

**The Hydrogen-Ion Concentration of Water.** ANDRÉ KLING and ARNOLD LASSIEUR. Ann. chim., 10: 15, 201-27, 1931. From Chem. Abst., 25: 4767, September 20, 1931. Detailed account of work mentioned in C. A., 25: 3222.—*R. E. Thompson.*

**Adsorption of Iron from Solutions by Precipitated Manganese Dioxide.** G. KREIMER. J. Chem. Ind. (Moscow), 7: 165-7, 1930; Chem. Zentr., 1930, II, 783. From Chem. Abst., 25: 4758, September 20, 1931. Aluminum sulfate solutions were freed of almost all iron by filtration through manganese dioxide. Iron is taken up by adsorption only.—*R. E. Thompson.*

**Electrolytic Production of Chlorine in Round Cells.** B. A. SASS-TISOVSKII. J. Chem. Ind. (Moscow), 7: 150-1, 1930. From Chem. Abst., 25: 4801, September 20, 1931. Discussion of the VORCE round cells (C. A. 14: 3198) and the WHEELER cells (Brit. pat. 102,049, 1916).—*R. E. Thompson.*

**The Corrosion of Locomotive Boilers.** LEO. BREARLEY and W. S. MACARTNEY. Commonwealth Eng., 18: 395-8, 1931. From Chem. Abst., 25: 4837, September 20, 1931. Pieces of iron threaded into pieces of copper were left in water of various alkalinities, oxygen contents, etc., and progress of corrosive action observed quantitatively. Basic causes of corrosion are solubility of iron in water and presence of dissolved oxygen in boiler waters. To control latter factor, it is recommended that any possibility of access of air to boiler be eliminated and that feed water be treated to remove oxygen. Tannin is recommended for this purpose, as it does not react with dissolved oxygen in cold and can therefore be introduced in reservoir, becoming active at boiler temperatures. It also precipitates calcium and magnesium as tannates, thus preventing boiler scale.—*R. E. Thompson.*

**Testing Butt Welds by Magnetic Methods.** T. R. WATTS. *Elec. J.*, 28: 389-91, 1931. From Chem. Abst., 25: 4838, September 20, 1931. Magneto-graphic inspection and weld test meters are discussed.—*R. E. Thompson.*

**Prevention of Electrolytic Corrosion of Underground Metallic Structures.** M. HORIOKA and M. IWASA. *Researches Electrotech. Lab. Tokyo, Japan*, No. 288, 82 pp., 1930; *Science Abstracts*, 34B, 53. From Chem. Abst., 25: 4836, September 20, 1931. Laboratory tests concerning range and degree of electrolytic corrosion were made by observing coloring of phenolphthalein for given positions of models of rails and underground structures immersed in neutral electrolyte stiffened by gelatin. Equipotential surfaces were traced in the electrolytic bath, by using telephone receiver as detector and passing current of 1000 ~ through rail. Insulating joints, when suitably placed, decrease sheath current and, therefore, electrolytic corrosion. Recommendations are made regarding most favorable location of insulating joints. As number of latter increases, sheath current tends to reach minimum value. Drainage connection eliminates electrolytic corrosion within certain region, whereas certain amount of local corrosion always occurs on higher potential side of insulating joint. Extent of space protected by drainage connection increases as resistance of metallic structure decreases and as resistance of path of leakage current flowing into return rail increases. Drainage of metallic structure nearest to rail return shields more distant structures to some extent; opposite effect is produced by an insulating joint.—*R. E. Thompson.*

**A Practical Method for the Preparation of Carbohydrate-Containing Culture Media for the Demonstration of Gas and Acid Formation.** STEPHAN LOUVREKOVITCH. *Zentr. Bakt. Parasitenk.*, 1 Abt., 115: 481-3, 1930. From Chem. Abst., 25: 4909, September 20, 1931. Medium is sterilized by filtration, not by heat, and is forced into inner inverted vials of DURHAM tubes by vacuum. An indicator is added.—*R. E. Thompson.*

**Pollution of the Upper Mississippi River.** JUDSON L. WICKS. *Trans. Am. Fish. Soc.*, 60: 286-96, 1930. From Chem. Abst., 25: 4953, September 20, 1931. A review.—*R. E. Thompson.*

**Pollution Problems in Ontario.** H. H. MACKAY. *Trans. Am. Fish. Soc.*, 60: 297-305, 1930. From Chem. Abst., 25: 4953, September 20, 1931. A review.—*R. E. Thompson.*

**Water Pollution in Ontario.** A. E. BERRY. *Trans. Am. Fish. Soc.*, 60: 306-10, 1930. From Chem. Abst., 25: 4953, September 20, 1931.—*R. E. Thompson.*

**Substitution of Ebonite Cocks at Filter Plants by Glass Tubes.** I. FRID. *J. Chem. Ind. (Moscow)*, 7: 282, 1930. From Chem. Abst., 25: 4952, September 20, 1931. Glass tubing, drawn to deliver desired amount of liquid per unit of time, are substituted for expensive ebonite cocks used for regulating flow of alum solution for coagulation.—*R. E. Thompson.*

**Chlorine Finds New Use in Treatment of Mill Water.** FRANCIS D. WEST. *Textile World*, 79: 144-6, 185, 1931. From *Chem. Abst.*, 25: 4952, September 20, 1931. Chlorine is recommended for treatment of industrial water supplies.—*R. E. Thompson.*

**Improved Methods of Water Purification Aid Textile Industry.** D. R. WEEDON. *Textile World*, 79: 2296-8, 1931. From *Chem. Abst.*, 25: 4952, September 20, 1931. Outline of present-day practice in water treatment for industrial purposes.—*R. E. Thompson.*

**Chemical Analysis of the Carbonated Mineral Water of Gornji Gabernik.** STANKO S. MIHOČIĆ. *Bull. soc. chim. roy. Yougoslav.*, 2: 1, 33-54 (in French, 54-6), 1931. From *Chem. Abst.*, 25: 4951, September 20, 1931. There are three theories regarding origin of carbonated mineral waters. (1) Carbon dioxide comes in contact with vadose water and dissolves therein: this water dissolves rocks on its way, starting with silicates, and forming principally carbonated alkalies. (2) Vadose water, which always contains certain amount of oxygen, comes in contact with pyrite schists and oxidizes latter, sulfuric acid formed dissolving carbonates and liberating carbon dioxide; latter, in turn, acting on silicates, dissolving them and forming carbonated alkalies. (3) Carbon dioxide is formed by decomposition and oxidation of organic matter. Author believes that carbonated mineral waters containing sodium are formed by oxidation of pyrites contained in carboniferous schists. Geological relations in region of Gornji Gabernik, as well as chemical composition of carboniferous schists, support this hypothesis.—*R. E. Thompson.*

**The Economic Development of Steam Generation in Germany. Results and Operating Expenses of Feed Water Preparation.** SPLITTGERBER. *Trans. 2nd World Power Conf. (Berlin)*, 7: 38-53, 1930. From *Chem. Abst.*, 25: 4952, September 20, 1931. Characteristics of chief mineral impurities in feed waters are given in extensive table. Water treated by various methods undergoes considerable salt enrichment in boiler. Maximum limit of salt content depends on necessity for preventing foaming, bumping, overboiling, etc., which in turn are governed by other factors, discussed in detail. Necessary ratio between dissolved sulfates and excess soda in water for preventing boiler scale cannot be maintained with high-pressure boilers. Sodium phosphate may be substituted for soda. A pH of 10 is necessary to prevent corrosion. Water should contain < 0.3 milligrams of oxygen per liter. Oil in water leads to overheating.—*R. E. Thompson.*

**Action of Aggressive Waters on Concrete.** HUGO VIERHELLER. *Bautenschutz*, 1: 2, 33-7, 1930; *J. Am. Concrete Inst.*, 2: Abstracts 215-6. From *Chem. Abst.*, 25: 4998, September 20, 1931. Corrosive action of aggressive waters on concrete may be either chemical, chemical and physical, or only physical, in nature. These factors must be considered when concrete is judged for its suitability for certain purposes. In first case, substances in water react with cement portion of concrete, dissolving, or weakening it. Agents acting in this manner are inorganic acids, some organic acids, and acid

salts. Protective coatings, or drainage of water, is advisable. Example of second type is the crystallization of new compounds formed by chemical reactions in interior of concrete with considerable increase in volume. This destroys interior structure and leads to softening of concrete. Purely physical action of water on concrete can be found in cases where water is taken up by capillary action, generating osmotic or crystalline pressure. This can appear without any chemical reaction and occurs in concrete of improper density. Structures only partly immersed in water are most likely to be affected in this way. Action of frost falls in this category. Dense concrete with sufficient impermeability is chief preventive measure. Directions are given for systematic investigation of different cements and concrete mixtures and of their stability in corrosive waters.—*R. E. Thompson.*

**The Sterilization of Water by Metals.** P. PETIT. *Brasserie et malterie*, 21: 97-101, 1931. From *Chem. Abst.*, 25: 4970, September 20, 1931. Results of DRÉNERT and ÉTRILLARD (*C. A.*, 25: 1927) are not applicable to beer, because presence of colloids prevents bactericidal action of metals such as silver.—*R. E. Thompson.*

**The Retrogradation of Javel Water.** ANDRÉ KLING and RENÉ SCHMUTZ. *Compt. rend.*, 192: 1655-7, 1931. From *Chem. Abst.*, 25: 5108, October 10, 1931. Under influence of sunlight (direct, or diffused), Javel water undergoes reversion in 2 different ways: (1) by decomposition to sodium chloride and oxygen and (2) by decomposition to sodium chlorate and sodium chloride. Method is outlined for determining relative progress of these two reactions based on amounts of chlorine set free by action of hydrochloric acid on hypochlorite and chlorate, respectively.—*R. E. Thompson.*

**Analysis of Alum by Means of pH Determinations.** G. KULLERUD. *Paper Trade J.*, 92: 21, 47-8, 1931. From *Chem. Abst.*, 25: 5111, October 10, 1931. Table is given of density  $18^{\circ}$  of solutions of highly purified aluminum sulfate, together with curves of pH values plotted against excess aluminum oxide or sulfuric acid for solutions of known density. By dissolving 60-70 grams aluminum sulfate in 200 grams of water and determining density and pH value (either electrometrically, or colorimetrically) of solution, excess alumina, or sulfuric acid, can be obtained directly by reference to curves.—*R. E. Thompson.*

**The Electrical Purification of Water.** JEAN BILLITER. *Trans. Electrochem. Soc. (preprint)*, 60: 8 pp., 1931. From *Chem. Abst.*, 25: 5227, October 10, 1931. Large-scale electrical purification of water in 3-compartment cell is not satisfactory, on account of high cost of diaphragms. New 2-compartment cell was devised, based on direct electrolysis of water, with but little electro-osmotic effect. Water with 150 to 600 milligrams per liter, and even more, of salt can be readily purified, product analyzing 6 to 9 milligrams of salt per liter. New cell embodies 2 diaphragms, one of ceramic material, the other of asbestos.—*R. E. Thompson.*

**Colorimetric Iron Determinations in Drinking Water and in Chalybeate Preparations.** K. SCHERINGA. Pharm. Weekblad, 68: 735-8, 1931. From Chem. Abst., 25: 5228, October 10, 1931. Method is essentially comparison of respective color reactions with potassium thiocyanate by sample and by standard iron solution.—R. E. Thompson.

**Iron Removal, Clarification, and Sterilization of the Water Supply of the City of Douala (Cameroon).** A. LANGUMIER. Arts & métiers, 1931, 267-9. From Chem. Abst., 25: 5228, October 10, 1931. Water is obtained from underground source and contains organically combined iron. Treatment with hypochlorite and ferrous ammonium sulfate (mixed just prior to use), followed by filtration, removes iron, clarifies, and effects sterilization. Equipment employed is described briefly.—R. E. Thompson.

**A Simple Method for Detecting the Phosphate Content (Determination) in Boiler Water.** PAUL KÖPPEL. Chem.-Ztg., 55: 539-40, 1931. From Chem. Abst., 25: 5229, October 10, 1931. To 1 cc. of filtered sample are added 5 granules of ammonium nitrate, and then 10 cc. of nitric acid and ammonium molybdate reagent, warmed to 70°. If precipitate plus yellow color is produced, phosphate content is too high: if yellow color only is produced after standing 1 or 2 minutes, phosphate content is correct for boiler purposes.—R. E. Thompson.

**Notes on the Exposure of Young Fish to Varying Concentrations of Arsenic.** A. H. WIEBE. Trans. Am. Fish. Soc., 60: 270-8, 1930. From Chem. Abst., 25: 5232, October 10, 1931. Vegetation in fish ponds can be controlled by application of from 1 to 2 p.p.m. arsenious oxide. Effects of varying concentrations of arsenious oxide were determined upon 7 species. Small fish are not seriously injured by concentrations of arsenic required to control vegetation. Short exposures of from 26 to 148 hours to concentrations as high as 7 p.p.m. did not affect fish adversely.—R. E. Thompson.

**Treatment of Water for the Textile Plant.** ESKEL NORDELL. Am. Dyestuff Repr., 20: 239-49; Proc. Am. Assoc. Textile Chem. Colorists, 1931, 137-47. From Chem. Abst., 25: 5294, October 10, 1931. Effects of impurities in water on cotton, silk, wool, and rayon processing are discussed. Alum and clay method of coagulation and decolorizing is described, and typical flow diagram of semi-automatic coagulation, settling, filtration, and zeolite softening plant is given. Economy effected by softening even "natural soft water" (1 to 4 grains hardness) is demonstrated.—R. E. Thompson.

**The Volumetric Analysis of Aluminium Sulfate and Sodium Acetate.** V. P. ZEMLYANITZUIN. J. Chem. Ind. (Moscow), 8: 629, 1931. From Chem. Abst., 25: 5365, October 20, 1931. Alum solutions may be analyzed by adding standard lime water, filtering, and titrating excess calcium hydroxide with hydrochloric acid.—R. E. Thompson.

**Injury to Underground Conducting Tubes and Cables from Stray Currents.** MEDINGER. Z. angew. Chem., 44: 550-1, 1931. From Chem. Abst., 25:

5354, October 20, 1931. Deposit on iron water mains in railroad tunnel showed analysis as follows: moisture, 24.5; ferric oxide, 48.6; chloride, 23.5 per cent; although surrounding earth contained only trace of chloride and water oozing from tunnel walls contained only 4 p.p.m. chloride. There was potential difference of 35 volts between water main and point in earth a few feet away and it is believed that deposit resulted from migration of chloride ions due to electric current. Laboratory experiment to prove this showed increase in chloride content of wash water from 4 to 56 p.p.m. with 8 volts applied. One corroded sample of anode material contained 5 percent chloride. Water containing 100 p.p.m. chloride passed over iron rust for 1 month without application of electric current showed no change in composition, and no basic chlorides formed on iron rust.—*R. E. Thompson.*

**Methods of Hydrochemical Analysis in Limnology.** I. G. J. WEREŠČAGIN with N. J. ANIČKOVA and T. B. FORSCH. *Arch. Hydrobiol.*, 23: 1-64, 167-230, 1931. From *Chem. Abst.*, 25: 5483, October 20, 1931. Field methods are given for determination of various constituents of lake waters, and apparatus and solutions required and convenient methods of packing are described. Bibliography of 117 references, classified.—*R. E. Thompson.*

**Tropical Inland Waters. Hydrographic and Hydrochemical Observations in Java, Sumatra, and Bali.** F. RUTTNER. *Arch. Hydrobiol.*, Suppl. vol. 8: 197-454, 1931. From *Chem. Abst.*, 25: 5482, October 20, 1931. Detailed results on stratification in 15 lakes are reported for temperature, conductivity, and various chemical constituents.—*R. E. Thompson.*

**Results of a Study of Lake Telećkoje.** S. LEPNEVA. *Arch. Hydrobiol.*, 23: 101-16, 1931. From *Chem. Abst.*, 25: 5482, October 20, 1931. Biology and thermal and chemical stratification of this oligotrophic lake in Central Asia is reported.—*R. E. Thompson.*

**Temperature and Oxygen Distribution in Lake Hallstatt.** FRIEDERICH MORTON. From *Chem. Abst.*, 25: 5482, October 20, 1931. A. **Thermics of Lake Hallstatt.** *Arch. Hydrobiol.*, 23: 117-37, 1931; cf. *C. A.*, 25: 4331. Variations of temperature with depth under various conditions during 1930 are reported. B. **Oxygen Distribution.** *Ibid.*, 138-56; cf. *C. A.*, 24: 178.—*R. E. Thompson.*

**The Chemical Constitution of Bleaching Powder.** SABURO URANO. *Proc. World Eng. Cong.*, Tokyo, 1929, 31: 171-80, 1931. From *Chem. Abst.*, 25: 5519, October 20, 1931. Bleaching powder is double salt,  $\text{Ca}(\text{OCl})_2 \cdot \text{CaCl}_2$ , with some water of crystallization in normal condition; but, having transition point at about 45°, it may pass from combined state to mixture of  $\text{Ca}(\text{OCl})_2$  and  $\text{CaCl}_2$  by heating and *vice versa* by cooling. Chlorine does not act upon calcium hydroxide directly, but first forms chlorine water with free water in lime: resulting hydrochloric and hypochlorous acids react with lime.—*R. E. Thompson.*

**Report on (the Determination of) Radioactivity in Drugs and Water.** J. W. SALE. *J. Assoc. Official Agr. Chem.*, 14: 309-11, 1931; cf. *C. A.*, 24: 5428. From *Chem. Abst.*, 25: 5507, October 20, 1931. Proposed method for determination of radioactivity of water is recommended for adoption as tentative standard method.—*R. E. Thompson.*

**The Determination of Magnesium by *o*-Hydroxyquinoline.** K. NEHRING. *Z. Pflanzenernähr., Düngung, u. Bodenk.*, 21A: 300-5, 1931. From *Chem. Abst.*, 25: 5486, October 20, 1931. Magnesium-*o*-hydroxyquinoline is precipitated in ammoniacal solution. Copper, zinc, cadmium, bismuth, aluminum, ferric iron, manganese, nickel, cobalt, calcium, etc., also give precipitates with this reagent. Reaction may be employed for determination of magnesium in soils and agricultural products. After precipitation, magnesium can be determined (1) as magnesium oxide by ignition with oxalic acid, (2) by direct weighing of precipitate, or (3) by titration with potassium bromate solution after addition of potassium bromide. In latter procedure, excess bromine is determined by addition of potassium iodide and thiosulfate titration. Magnesium can be determined in presence of calcium by precipitation of latter as oxalate in presence of acetate radical and subsequent precipitation of magnesium with reagent and titration by bromate method.—*R. E. Thompson.*

**Comparison of the Water Solubilities of Three Different Cements.** DONOVAN WERNER. *Zement*, 20: 626-30, 1931. From *Chem. Abst.*, 25: 5536, October 20, 1931. Apparatus is described which was used to determine solution rates of cement and of mixtures in triplicate under carbon-dioxide-free conditions. It is shown that solution is incongruous; that calcium oxide is most soluble constituent in cement; that solubility of calcium oxide is practically unaffected by age of concrete, or quantity of mixing water used within limits observed; and that rate of solution of calcium oxide decreases with time. With aluminous cement, alumina paralleled calcium oxide in solution tendencies, being slightly more soluble than latter.—*R. E. Thompson.*

**Treating Water with Chlorine.** Wallace and Tiernan Products, Inc. *Brit.* 345,637, December 18, 1929. From *Chem. Abst.*, 25: 5485, October 20, 1931. Chlorine is added (suitably in proportion of 0.75 p.p.m. during periods of 1 minute with intervals of 10 minutes) to prevent formation of films and scums on flowing water, or aqueous liquids, such as cooling water of surface condensers. Automatic apparatus is described for controlling addition of the chlorine.—*R. E. Thompson.*

**Microchemical Reactions for Copper.** K. M. FILIMONOVICH. *Ukrainskii Khim. Zhur.*, 5: Sci. Pt., 383-6, 1930. From *Chem. Abst.*, 25: 5640, November 10, 1931. Decolorization of ferric thiocyanate solution by sodium thiosulfate is accelerated by divalent copper. In this way copper can be detected in presence of all other cations. If solution containing divalent manganese is treated with sodium hydroxide and sodium hypobromite on boiling, insoluble manganous acid is formed, but if divalent copper is present, permanganic

acid is formed. This reaction also serves for microchemical detection of divalent copper.—*R. E. Thompson.*

**New Method of Microdetermination of the Copper Ion.** CHRISTIAN ZBINDEN. *Bull. soc. chim. biol.*, 13: 35-40, 1931. From *Chem. Abst.*, 25: 5642, November 10, 1931. Electrometric titration method is described which is rapid and accurate to  $\pm 3.3$  percent with 0.00636 milligram copper. After deposition on platinum electrode, current is reversed and kept constant by slight adjustment of potential. Sharp drop in current occurs when all copper has been redissolved. Copper is calculated from current consumption.—*R. E. Thompson.*

**Water-Softening Practice in Great Britain.** DAVID BROWNLIE. *Combustion*, 1: 7, 39-44, 1930. From *Chem. Abst.*, 25: 5722, November 10, 1931. Review.—*R. E. Thompson.*

**A Colorimetric Method for the Determination of Traces of Potassium.** JOSEPH FISCHER. *Biochem. Z.*, 238: 148-61, 1931. From *Chem. Abst.*, 25: 5641, November 10, 1931. For determination of from 0.001 to 1.0 milligram of potassium, method is described which depends upon formation of  $K_2NaCo(NO_2)_6$ ; well-washed precipitate is dissolved in hot water and colorimetric determination of nitrite is made by utilizing very sensitive test of RIEGLER. As reagent, solution of 5 grams of sodium naphthionate and 2.5 grams of  $\beta$ -naphthol in 500 cc. water is recommended.—*R. E. Thompson.*

**Comparison of Various Sizes of Test Bars Representing Cast Irons from Five Foundries.** HYMAN BORNSTEIN. *Proc. Am. Soc. Testing Materials*, Preprint, 11: 5-12, 1931. From *Chem. Abst.*, 25: 5652, November 10, 1931. Bars 0.75, 1.2, 2.0 and 3.0 inches in diameter were cast of various grades of cast iron with varying percentages of steel. Micrographs and data on physical qualities are presented, and tensile strength and Brinell hardness of bars are plotted against diameters. Higher-strength iron shows less falling off in physical properties, from light to heavy section, than lower-strength iron.—*R. E. Thompson.*

**Tests on Cast Iron Specimens of Various Diameters.** J. T. MACKENZIE. *Proc. Am. Soc. Testing Materials*, Preprint, 11: 13-8, 1931. From *Chem. Abst.*, 25: 5653, November 10, 1931. In order to determine constancy of relationship between 3 sizes of test bars proposed as standard for cast iron, 0.875, 1.20, and 2.20 inches in diameter respectively, numerous determinations of modulus of rupture, modulus of elasticity, deflection, and Brinell hardness were carried out. Influence of dimensions of bars upon physical characteristics are shown in graph form.—*R. E. Thompson.*

**Phosphate Treatment of Boiler Water.** EDWARD P. PRICE. *Combustion* 1: 7, 35-8, 1930. From *Chem. Abst.*, 25: 5722, November 10, 1931.—*R. E. Thompson.*

**Graphical Method for the Reagents Used in the Soda-Lime Treatment of Water.** YU. M. KOSTRIKIN. *Izvestiya Teplotekhnicheskago Inst.* (Trans.

Thermo-Tech. Inst. Russia), 1931: 5, 26-9. From Chem. Abst., 25: 5721, November 10, 1931. Charts given for various reactions which occur in lime-soda softening, and their use illustrated.—*R. E. Thompson.*

**Determination of Iron in Water.** O. MAYER. *Z. Untersuch. Lebensm.*, 60: 195-210, 1930. From Chem. Abst., 25: 5721, November 10, 1931. For determination of total iron, where only small quantities are present, residue after evaporation and ignition is taken up with dilute (1.5) hydrochloric acid and 10 percent thiocyanate solution and diluted to suitable volume. Similar volume of thiocyanate-acid mixture is titrated with iron solution of known concentration to color equality with sample. For iron contents above 10 p.p.m., residue after evaporation and ignition is dissolved in sulfuric acid, and, after reduction with zinc, solution is titrated with permanganate. For determining inorganically combined iron, 100 cc. of water is mixed with 1 cc. of concentrated hydrochloric acid containing trace of bromine, and, after 1 or 2 minutes, 2 cc. of thiocyanate solution and then 10 cc. of ether-amyl-alcohol are added. On shaking and standing, alcohol layer contains about 60 percent of iron. Similar volume of distilled water mixed with identical volumes of reagents is titrated with standard iron solution until amyl alcohol layers are of equal color. Ferric ions may be determined directly by siphoning 100 cc. of water into vessel filled with carbon dioxide, and adding 1 cc. of hydrochloric acid (density 1.19) and 2 cc. of 50 percent thiocyanate solution. Color (concentrated if necessary by shaking with 5 to 10 cc. amyl alcohol) is compared with that of similarly treated iron solution of known concentration. Ferrous ions cannot be determined directly, but are given by difference between inorganic iron and ferric ions. Organically combined iron is given by difference between total iron and inorganic iron.—*R. E. Thompson.*

**Volumetric Determination of Sulfate.** D. NORTHALL-LAURIE. *Analyst*, 56: 526-7, 1931. From Chem. Abst., 25: 5722, November 10, 1931. To determine sulfate in boiler feed water, add to 100 cc. of sample in 300-cc. conical flask 10 drops of phenolphthalein and titrate to colorless with 0.1-normal acid. Add 10 to 20 cc. of neutral barium carbonate suspension and titrate alkali carbonate formed slowly and carefully with dilute acid until carbonate is converted to bicarbonate (colorless to phenolphthalein).—*R. E. Thompson.*

**Critical Remarks on the Determination of Silicic Acid in Mineral Waters.** FRANZ HUNDESHAGEN and F. W. SIEBER. *Z. angew. Chem.*, 44: 683-5, 1931. From Chem. Abst., 25: 5722, November 10, 1931. Advertisements concerning German mineral waters have recently laid great stress upon abnormally high silica content, which is assumed to exert valuable medicinal effects. Examinations by authors showed published contents to be much too high. High silica results may have been due to faulty analyses, to action of water upon glass, or to installation of new masonry.—*R. E. Thompson.*

**The Preventive Purifying of the Water Supply for Locomotives and Related Plants (Italian State Railways).** ARCHIMEDE MICHELBUCCI. *Proc. World Eng. Congr., Tokyo*, 1929, 15: 201-11, 1931. From Chem. Abst., 25: 5722,

November 10, 1931. Water softening systems used by Italian State Railways are described and performance data are given.—*R. E. Thompson.*

**De-aeration of Fresh Feed Water Added to the Condensate from Turbines.** YA. M. RUBINSTEIN and A. N. TREGUBOV. *Izvestiya Teplotekhnicheskago Inst. (Trans. Thermo-Tech. Inst. Russia)*, 1931: 6, 43-53. From Chem. Abst., 25: 5722, November 10, 1931. Fresh feed water was admitted into line through which steam from turbine was passed to condenser. Mechanical part is described in great detail and results of analyses are given.—*R. E. Thompson.*

**Chemical and Physical Reactions of Sodium Aluminate When Used in Boiler Feed Water.** J. A. HOLMES. *Combustion*, 2: 7, 26-9, 1931. From Chem. Abst., 25: 5723, November 10, 1931. Use of sodium aluminate internally in low-pressure boilers is discussed.—*R. E. Thompson.*

**Proposed Standard for Analyzing Boiler Scale.** YU. M. KOSTRIKIN. *Izvestiya Teplotekhnicheskago Inst. (Trans. Thermo-Tech. Inst. Russia)*, 1931: 5, 19-26. From Chem. Abst., 25: 5723, November 10, 1931. Hygroscopicity, loss through heating to incandescence, and mineral constituents are determined.—*R. E. Thompson.*

**Waterworks and Sewerage in Japan.** ISAMU KUSAMA. *Proc. World Eng. Congr., Tokyo*, 1929, 12: 21-37, 1931. From Chem. Abst., 25: 5723, November 10, 1931. Water purification in Japan is discussed.—*R. E. Thompson.*

**Electrolytic Corrosion of Underground Cable in Japan.** SHICHIJIRO NUMATA. *Proc. World Eng. Cong., Tokyo*, 1929, 19: 531-52, 1931. From Chem. Abst., 25: 5853, November 20, 1931. Corrosion readily occurs in ground water containing hydrochloric or carbonic acids. Lead chloride, lead carbonate, and lead dioxide are typical corrosion products. Various factors contributing to corrosion and correction methods are discussed.—*R. E. Thompson.*

**The Cause of Mottled Enamel.** MARGARET C. SMITH, EDITH M. LANTZ and H. V. SMITH. *Science*, 74: 244, 1931; cf. *C. A.*, 25: 539. From Chem. Abst., 25: 5926, November 20, 1931. Preliminary report of investigation into causes of tooth defect known as mottled enamel. Fluorine content of community water supplies is thought to be the active agent.—*R. E. Thompson.*

**The Regeneration of Base-Exchange Water-Softening Materials.** E. M. PARTRIDGE. *Combustion*, 2: 4, 31-4, 1930. From Chem. Abst., 25: 5945, November 20, 1931.—*R. E. Thompson.*

**Methods of Precipitating with 8-Hydroxyquinoline (Oxine).** I. Magnesium. **Precipitation: Titration of the Excess Reagent.** FRIEDRICH L. HAHN. *Z. anal. Chem.*, 86: 153-7, 1931. From Chem. Abst., 25: 5868, November 20, 1931. Although use of oxine has been warmly recommended by many, unsatisfactory results have sometimes been obtained. Study of causes of failure has led to improved procedure. As reagent, dissolve 38 grams oxine in 125

to 130 cc. of 2-normal hydrochloric acid and dilute to 1 liter. For titration of oxine, dissolve 28 grams potassium bromate and 50 grams potassium bromide in water and dilute to 1 liter. To 20 cc. of solution containing from 5 to 100 milligrams magnesium in 250-cc. measuring flask, and 2 or 3 grams ammonium chloride, 2 or 3 cc. concentrated ammonium hydroxide, and 20 cc. acetone. Heat gently on water bath until near boiling and then add oxine solution slowly from buret, until supernatant has yellow tint, adding more acetone if necessary, to keep final concentration about 50 per cent. If considerable reagent is necessary, heat the solution from time to time during addition. Finally add 10 cc. more of acetone, dilute with water to about 200 cc. and allow to stand at least 1 hour. Make up to mark, mix, and filter. Discard first 50 cc. filtrate and take next 100 cc. for further analysis. Transfer this to evaporating dish, make acid to phenolphthalein by adding acetic acid, add 5 cc. of 5 per cent zinc sulfate solution and evaporate half an hour on water bath. Pour into Erlenmeyer flask, rinse out dish with 30 cc. concentrated hydrochloric acid, and add excess of bromate; determine excess bromate by adding potassium iodide and titrating with sodium thiosulfate. One Mg reacts with 2 molecules oxine and is equivalent to  $\frac{1}{3}$  molecule of  $\text{BrO}_3$ . Results in analysis of about 5 milligrams of magnesium agreed within 0.6 per cent.—*R. E. Thompson.*

**Hot-Process Softener Compared with Evaporator.** J. D. YODER. *Power*, 74: 496-7, 1931. From *Chem. Abst.*, 25: 5945, November 20, 1931. Hot-process softener is usually more economical than an evaporator. Data are given from which relative costs may be calculated.—*R. E. Thompson.*

**New Process for the Determination of Small Amounts of Bromide in Chloride.** B. S. EVANS. *Analyst*, 56: 590-3, 1931. From *Chem. Abst.*, 25: 5871, November 20, 1931. In 8- to 9-normal sulfuric acid solution, chromic acid oxidizes bromide to bromine rapidly and completely without acting upon chloride. To aqueous solution, in flask with ground-glass stopper carrying funnel tube and gas-exit tube, add one-third as much concentrated sulfuric acid and about 5 grams chromic anhydride. Connect flask with another containing standard sodium arsenite solution and sodium bicarbonate. Draw a steady stream of air through apparatus for 1 hour at room temperature and then titrate excess arsenite with standard iodine solution.—*R. E. Thompson.*

**Detection of Fluoride.** LOUIS J. CURTMAN and L. AUERBACH. *Chem. News*, 143: 180-2, 1931. From *Chem. Abst.*, 25: 5871, November 20, 1931. As little as 0.1 milligram fluorine can be detected by precipitation as calcium fluoride under proper conditions. To determine fluorine in mineral powder containing silicate, fuse 1 gram of sample with 10 grams sodium carbonate in platinum. Leach melt with 250 cc. hot water, filter, and evaporate filtrate to 75 cc. To one-sixth of this solution, add 40 cc. of 4-normal ammonium carbonate solution, heat to boiling, and allow to stand overnight. Filter off silica precipitate and evaporate to 30 cc. Neutralize to phenolphthalein with 3-normal hydrochloric acid until only faint pink color is obtained by heating and expelling carbon dioxide; then add 7 cc. of 2-normal calcium chloride solution. Precipitate obtained at this point will be calcium fluoride

mixed with calcium carbonate. Filter and apply etching test to precipitate. If borate is present, interference is avoided by adding 5 grams of ammonium chloride before neutralizing the solution. To detect fluoride in water-soluble sample which may contain chlorate, it is advisable to decompose chlorate by heating dry powder in nickel crucible before attempting to apply etching test.—R. E. Thompson.

**New Electrometric Method for the Analysis of Hypochlorite Solutions.** M. ABRIBAT. Bull. soc. chim., 49: 1119-38, 1931. From Chem. Abst., 25: 5873, November 20, 1931. A platinum electrode dipping in solution of hypochlorite containing dilute hydrochloric acid shows series of stable potentials depending upon quantity of acid added. Plotting e.m.f. against volume of added acid gives curve with several distinct inflection points by means of which free alkali, carbonate, combined  $\text{ClO}^-$ , and free total  $\text{ClO}^-$  can be determined. Difference between combined and total  $\text{ClO}^-$  gives hypochlorous acid content. Second titration made with solution freed from carbonate by precipitation as calcium carbonate gives  $\text{ClO}_2^-$  value if any is present. Determination of soluble chloride, which is always present, can easily be made by classic electrometric method with electrode of silver and titrated solution of silver nitrate.—R. E. Thompson.

**The Essential Factors of the Mechanism of Corrosion of Iron and Steel.** TADAYOSHI FUJIHARA. Proc. World Eng. Congr., Tokyo, 1929, 34: 25-38, 1931. From Chem. Abst., 25: 5887, November 20, 1931. Hydrogen ion in water attacks iron with evolution of hydrogen. This evolution may stop by overvoltage. Dissolved oxygen acts as depolarizer and iron continues to dissolve. Dissolved ferrous iron may be oxidized by dissolved oxygen to ferric hydroxide, which eventually becomes rust. The dissolved iron, the soluble hydroxide of which is alkaline, protects the metal. This alkaline protective film is neutralized and attacked by carbonic acid, permitting corrosion to proceed. Inclusions promote corrosion by causing galvanic action. Rust shields portion which it covers from oxygen so as to render it anodic. Resulting corrosion is concentrated over limited area.—R. E. Thompson.

**Corrosion: What It Is.** W. S. JOHNSTON. Power, 74: 87-9, 121-3, 155-7, 1931. From Chem. Abst., 25: 5886, November 20, 1931. Loss through corrosion of iron and steel is about 2 per cent per year. Author discusses common types of corrosion, non-corrosive alloys, and protective coatings.—R. E. Thompson.

**Is Soft Water the Criterion of Scale Prevention.** A. R. MOBERG and E. M. PARTRIDGE. Combustion, 1: 9, 21-3, 1930. From Chem. Abst., 25: 5945, November 20, 1931. Soft water is not the criterion of scale prevention. Presence of magnesium carbonate reduces solubility of calcium carbonate and allows preferential formation of non-scale-forming salts.—R. E. Thompson.

**The Corrosion of Steamship Boilers and Its Prevention by Feed-Water Treatment.** H. JANNSEN. Korrosion u. Metallschutz, 7: 108-11, 1931. From

Chem. Abst., 25: 5945, November 20, 1931. Most important cause of corrosion in marine boilers is hydrochloric acid generated from magnesium and ferrous chlorides. Dosing feed water with sodium hydroxide minimizes corrosion by reducing quantity of hydrochloric acid that passes from feed-water evaporator to boiler.—*R. E. Thompson.*

**Corrosion (of Boiler Tubes).** B. W. WHITEFIELD. Rept. Sudan Government Chem., Chem. Sec. Pub., 61: 47-9, 1930; 63: 29, 1931. From Chem. Abst., 25: 5945, November 20, 1931. Corrosion of iron in sulfate and chloride waters was increased by contact with copper, but copper decreased tendency toward pitting produced by use of alkaline corrosion inhibitors, such as sodium carbonate and hydroxide. Laboratory experiments carried out over temperature range of 25° to 100°, with saline water containing dissolved oxygen, indicated that much more corrosion takes place while temperature of water is being raised from 25° to 100° than while air-free water is boiling steadily at 100°.—*R. E. Thompson.*

**Phosphate Deposits Eliminated by Quick Feed.** A. B. STICKNEY. Power, 73: 947, 1931. From Chem. Abst., 25: 5945, November 20, 1931. Treating boiler feed water with phosphate kept boiler free from scale, but resulted in scale deposit in lines and heaters. Problem was solved by introducing concentrated phosphate solution rapidly with long intervening periods.—*R. E. Thompson.*

**Hot Lime Soda Phosphate Treatment of Feed Water for High-Pressure Boilers.** C. E. JOOS. Combustion, 2: 1, 19-23, 50, 1930. From Chem. Abst., 25: 5945, November 20, 1931. Feed-water treatment with lime soda is not satisfactory for high-pressure boilers and supplementary treatment with phosphate should be used. Lime treatment, sedimentation, and filtration should precede phosphate addition.—*R. E. Thompson.*

**Boiler Feed Water Analysis and Their Interpretation.** J. D. YODER. Power, 73: 1021-3, 1931. From Chem. Abst., 25: 5945, November 20, 1931. "Ionic" and "combined" methods of reporting analyses are explained.—*R. E. Thompson.*

**Sulfate of Alumina and the Alums.** J. J. HEALY, JR. Paper Trade J., 93: 14, 38-40, 1931. From Chem. Abst., 25: 5957, November 20, 1931. Brief description of sources and of method of manufacture.—*R. E. Thompson.*

**New Bleach and Chlorine Control Equipment.** F. R. MCCRUMB. Paper Mill, 54: 37, 5; Pulp Paper Mag. Can., 30: 1077, 1931. From Chem. Abst., 25: 5988, November 20, 1931. Description of chlorine slide colorimeter for simple and rapid determination of free chlorine.—*R. E. Thompson.*

**The Compression of Liquid Water.** ROBERT C. H. HECK. Power, 74: 422-4, 1931; cf. KEENAN, C. A., 25: 2036. From Chem. Abst., 26: 14, January 10, 1932. Curves show heat required to bring water from 32° to boiling point

at constant pressure. The data apply to practical problems of feed-water heating.—*R. E. Thompson.*

**A New Development in Sodium Chloride Electrolysis.** HEINRICH PAWECK. *Z. Elektrochem.*, 37: 724-5, 1931. From *Chem. Abst.*, 26: 21, January 10, 1932. New type of diaphragm made up of sodium chloride is described. Lining of cement cell with non-porous blocks of sodium chloride is also an improvement.—*R. E. Thompson.*

**Effect of Neutral Electrolytes on the Aggressiveness of Water Toward Calcium Carbonate.** I. E. ORLOV. *Z. anorg. allgem. Chem.*, 200: 87-104, 1931; cf. *C. A.*, 24: 4564. From *Chem. Abst.*, 26: 21, January 10, 1932. In presence of electrolytes, equation for action of hydrogen and bicarbonate ions on solid calcium carbonate still applies, except that coefficients differ. Their change approximates change in ionic activity of concentrated electrolyte solutions. Equation is developed for calculating aggressiveness of any electrolyte solution.—*R. E. Thompson.*

**Studies on the Transformations of Iron in Nature. III. The Effect of Carbon Dioxide on the Equilibrium in Iron Solutions.** H. O. HALVORSON. *Soil Science*, 32: 141-65, 1931; cf. *C. A.*, 22: 1990. From *Chem. Abst.*, 26: 21, January 10, 1932. Study is made of equilibrium conditions in iron solution under influence of atmospheric oxygen and carbon dioxide. Equations are developed expressing equilibrium conditions. Activities of microorganisms in these solutions are studied. Under anaerobic conditions, in dextrose or peptone media, heterotrophic microorganisms may dissolve metallic iron. They will also dissolve and reduce iron present as ferric hydroxide. These reactions result in formation of acid, but may occur at reactions close to neutrality. Precipitation of ferrous carbonate may result when carbon dioxide is formed by breakdown of organic compounds. Iron content of natural water in iron springs is not reduced by iron bacteria to concentration below that to which it will go by chemical action alone. Solution and precipitation of iron in nature are associated with equilibrium conditions which depend upon tensions of oxygen and of carbon dioxide, acid, and presence of organic compounds. It appears that importance of true iron bacteria has been over-emphasized, whereas importance of heterotrophic bacteria in transformation of iron in nature has not been fully appreciated.—*R. E. Thompson.*

**Sand Filtration of Water.** F. DIÉNERT. *Eau*, 24: 34-7, 1931. From *Chem. Abst.*, 26: 226, January 10, 1932. Paris system of slow sand filtration is discussed.—*R. E. Thompson.*

**Determination of Chlorides with the Highest Accuracy.** ANCEL B. KEYS. *J. Chem. Soc.*, 1931: 2440-7. From *Chem. Abst.*, 26: 47, January 10, 1932. Method described is a micro-VOLHARD titration with syringe pipets to deliver  $\frac{1}{2}$ -cc. portions of chloride solution and silver nitrate reagent. Results are accurate to about 0.001 milligram of chloride. One analyst can make over 50 determinations per day.—*R. E. Thompson.*

**The Colorimetric Determination of Silicic Acid, Particularly in Water.** OTTO LIEBKNECHT, LOTHAR GERB and ERICH BAUER. *Z. angew. Chem.*, **44**: 860-3, 1931. From Chem. Abst., **26**: 49, January 10, 1932. Yellow coloration produced on addition of ammonium molybdate to acid solution of silica is used advantageously for colorimetric determination of silica in waters, with picric acid solutions as standards. There are 3 principal difficulties to overcome in determining small quantities of silica: (1) phosphoric acid causes similar coloration; (2) ferric iron gives brown color with silicomolybdic acid; and (3) some silica is likely to be dissolved from glass during analysis. Removal of iron and phosphate is best accomplished as follows. To 50 or 100 cc. of sample add 3 cc. disodium phosphate (18.6 grams  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  in 200 cc. water),  $\frac{1}{2}$  cc. calcium chloride solution (20 grams  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  in 100 cc. water), and 1 gram calcium carbonate. Heat 10 minutes on boiling water bath with frequent shaking, filter hot, wash once with hot water, and treat with acid and molybdate in unusual manner. To correct for silica dissolved from glass, use Jena flasks that have had several treatments with hot, dilute alkali solution, and carry out determination with known amount of silica.—*R. E. Thompson.*

**Some Experiments Which Support the Fact that Oxygen Promotes in Two Ways the Corrosion of Iron and Steel in Aqueous Solutions.** HIKOGO ENDO and SHIGENORI KANAZAWA. *Proc. World Eng. Congr., Tokyo 1929*, **34**: 251-60, 1931. From Chem. Abst., **26**: 69, January 10, 1932. Oxygen aids solution of iron (primary stage of corrosion), oxidizes hydrogen film, and precipitates dissolved ferrous iron (secondary stage).—*R. E. Thompson.*

**Soil-Corrosion Studies, 1930. Rates of Corrosion and Pitting of Bare Ferrous Specimens.** K. H. LOGAN and V. A. GRODSKY. *Bur. of Standards J. Research*, **7**: 1-35, 1931. From Chem. Abst., **26**: 70, January 10, 1932. Data on loss of weight and pitting of specimens of various types of ferrous metals buried 8 years in 47 soils are given, together with data obtained in each previous 2-year period. In general, rate of attack decreases with time. Vast differences are shown in corrosiveness of different soils. Data so far obtained do not indicate that any one of commonly used pipe materials is markedly superior to others for general underground use. If soil is corrosive with respect to one ferrous material, it is corrosive to others also. Other things being equal, the thicker the specimen, the lower will be its rate of deterioration if test is continued until puncture occurs. This observation has very practical application to selection of wall thickness for pipes which are laid without protection in corrosive soils.—*R. E. Thompson.*

**Measuring the Electrical Resistance of Mineral Waters in the Field.** A. GUILLERD. *Ann. fals.*, **24**: 411-22, 1931. From Chem. Abst., **26**: 225, January 10, 1932. Value of electrical conductivity measurements for control of mineral waters is shown. Portable apparatus for carrying out such determinations in field is described.—*R. E. Thompson.*

**Removal of Boiler-Scale Deposits from Hot Water Apparatus.** FRITZ HINDEN. *Monats-Bull. Schweiz. Ver. Gas-u. Wasserfach*, **11**: 259-60, 1931. From Chem.

Abst., 26: 229, January 10, 1932. Experiments were made on attack of zinc, aluminum, tin, copper, and brass by dilute hydrochloric, formic, and acetic acids as used for scale removal. It is concluded that 8 to 10 percent hydrochloric acid is most suitable for copper or brass apparatus; 5 to 10 percent formic acid for aluminum, or tinned metals; and 15 percent acetic acid for zinc, or galvanized iron.—*R. E. Thompson.*

**The Decolorization of Colored Natural Waters and Aqueous Extracts of Soil and Turf.** B. A. SKOPINTZEW. *Z. anal. Chem.*, 86: 219-35, 1931. From *Chem. Abst.*, 26: 48, January 10, 1932. Considerable experimental work was undertaken to determine best method of decolorizing water or aqueous soil extracts prior to colorimetric determination of ammonia, nitrite, and nitrate. Treatment with aluminum sulfate and potassium hydroxide gave best results. Original color of water is best removed at pH about 5. Potassium sulfate formed has no effect on determinations, although when considerable amount is present, dry residue must be heated for a minute on water bath with the phenol-disulfonate reagent to effect thorough mixing in the nitrate test. Content of ammonia and nitrite is practically unchanged by adsorption by aluminum hydroxide precipitate when pH is between 5.0 and 7.0; nitrate loss may be as much as 4 milligrams per liter, but at pH 4.5-5.0 no loss occurs. When humus content corresponds to 300° of color, there is loss of 15 percent of nitrate if pH is higher than 5, but there is no loss at pH less than 4.5. With 1000° of color there was appreciable loss at all pH values (4.5 to 7), but only 10 per cent loss with small quantities of nitrate when pH was 4.5. Following procedure is recommended: to from 200 to 400 cc. of colored solution, add, for each 100 cc. of sample, 0.5, 1.0 or 2.0 cc. (according to color) of 13 percent  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ , shake well, add respectively, 0.4, 0.9, for 1.8 cc. of 7 percent potassium hydroxide, again shake, and allow to stand. Use aliquots for determinations. If original water is hard, or rich in carbonate, correction for same should be made in volume of potash used. Bibliography appended.—*R. E. Thompson.*

**Action of Forests on the Regulation of Water and on Rainfall.** NEVEUX. *Eau*, 24: 68-72, 1931. From *Chem. Abst.*, 26: 226, January 10, 1932. Forests not only increase rainfall, but also conserve water which has fallen.—*R. E. Thompson.*

**Cause of Mottled Enamel, a Defect of Human Teeth.** MARGARET CAMMACK SMITH, EDITH M. LANTZ and H. V. SMITH. *Arizona Agr. Expt. Sta., Tech. Bull.* 32: 254-82, 1931; cf. *C. A.*, 25: 5926. From *Chem. Abst.*, 26: 184, January 10, 1932. Mottled enamel is endemic at St. David, Ariz. Every child exposed to environmental conditions of the community during years of growth had mottled enamel. With dogs and cats as experimental animals, mottled enamel was reproduced in teeth when given St. David's water to drink over period of time, or if given foods cooked with this water. Chemical examination of water showed presence of from 3.6 to 7.15 p.p.m. of fluorine. Water supplies from non-endemic localities showed from 0 to 0.3 p.p.m. Condition of mottled enamel is proved to be caused by fluorine. Animals fed on diets low

in calcium developed mottled teeth at earlier date, when given fluorine, than control animals on normal calcium diet plus fluorine.—*R. E. Thompson.*

**Use of Gaseous Chlorine in Water Purification (at Paris).** F. DIÉNERT. *Eau*, 24: 53, 1931. From *Chem. Abst.*, 26: 227, January 10, 1932. At Ivry and St. Maur stations, near Paris, chlorine was substituted for usual sodium, or calcium, hypochlorite with excellent results from standpoints both of labor saving and of effectiveness.—*R. E. Thompson.*

**Water Purification and Sewage Disposal on the Great Lakes.** JOSEPH W. ELLMS. *Sci. Monthly*, 33: 423-7, 1931. From *Chem. Abst.*, 26: 230, January 10, 1932.—*R. E. Thompson.*

**Portable Electrical Fluoroscope for Detection of Fluorescein.** DIÉNERT and GUILLERD. *Tech. sanit. munic.*, 26: 192-3, 1931. From *Chem. Abst.*, 26: 230, January 10, 1932. Apparatus described detects 1 part of fluorescein in 10 billion.—*R. E. Thompson.*

**Active Carbon: Its Applications in the Hygiene of Air and Water.** R. CAMBIER. *Ann. hyg. publ. ind. sociale*, 1931: 217-29. From *Chem. Abst.*, 26: 232, January 10, 1932.—*R. E. Thompson.*

**Physical-Chemical Considerations on the Question of the Foaming of Boiler Waters.** FRITZ NIEHAUS. *Vom Wasser*, 4: 140-53, 1930. From *Chem. Abst.*, 26: 228, January 10, 1932. Modern-type boilers have brought with them troublesome foaming and wetting of steam, with resulting salt incrustations and burning out of boiler pipes. This tendency can be greatly reduced by proper boiler construction, and completely eliminated by proper boiler feed water treatment. Conditions necessary to foam formation in a liquid are: (1) heterogenous boundary surface layer, i.e., one consisting of different kinds of molecules; (2) concentration gradient between surface and interior of solution. Factors influencing foaming, surface tension, viscosity, salt content, etc., are discussed. Specific suggestions and precautions for feed water treatment are included.—*R. E. Thompson.*

**The Effect of Boiler Scale on Heat Transmission and Utilization.** A. POLITT. *J. Inst. of Fuel*, 4: 285-6, 1931. From *Chem. Abst.*, 26: 229, January 10, 1932. Scale does not seriously affect boiler efficiency, as formerly supposed. Because of its low heat conductivity, scale may cause temperature of boiler tubes to rise excessively.—*R. E. Thompson.*

**Technic of Isolation and Identification of Bacteria in Water.** R. DUJARRIC DE LA RIVIÈRE and T. H. CHU. *Rev. hyg. med. prèv.*, 53: 241-57, 1931. From *Chem. Abst.*, 26: 232, January 10, 1932.—*R. E. Thompson.*

**Softening Water.** CHARLES P. HOOVER. U. S. 1,823,605, September 15. From *Chem. Abst.*, 26: 234, January 10, 1932. For reducing carbonate hardness to approximately theoretical solubility limit of calcium carbonate and

magnesium hydroxide, hard water is treated with 25 to 50 p.p.m. or more of lime in excess of that theoretically required to combine with free and half-bound carbon dioxide and precipitate the magnesium, mixture is permitted to settle, supernatant water is carbonated with carbon dioxide gas, sufficient calcium carbonate is added to accelerate precipitation, and precipitate is separated.—*R. E. Thompson.*

**The Action Exerted by Hypochlorites on Bacteria Suspended in Water Agitated Violently.** G. ROSSETTI. *Boll. soc. ital. biol. sper.*, 6: 102-6, 1931. From *Chem. Abst.*, 26: 255, January 10, 1932. Violent agitation increases disinfecting action of chlorine. Evidence is given that small doses of chlorine (0.1 to 0.3 p.p.m.) exert disinfecting action by production of ultra-violet rays.—*R. E. Thompson.*

**A Study of Commercial Solutions of Sodium Hypochlorite.** FRANCISCO HERNÁNDEZ. *Quím. e. ind.*, 8: 173-80, 1931. From *Chem. Abst.*, 26: 260, January 10, 1932. Light has great effect on decomposition velocity of sodium hypochlorite solutions. Of less effect are atmospheric air, particularly with high carbon dioxide content, temperature above 25°, and presence of as little as 0.001 percent ferric oxide.—*R. E. Thompson.*

**The Aggressivity of Salt Solution.** I. E. ORLOV. *J. Chem. Ind. (Moscow)*, 8: 863-4, 1931; cf. *C. A.* 24, 4564. From *Chem. Abst.*, 26: 260, January 10, 1932. Sodium chloride increases rate of solution of calcium carbonate in solutions containing carbonic acid. Sulfates act even more rapidly than chlorides. In presence of hydrogen ions these salts are still more active. Equations are derived to support these facts.—*R. E. Thompson.*

**Water-Distillation Apparatus.** A. SCHLEEDÉ and E. KÖRNER. *Chem.-Ztg.*, 55: 808, 1931. From *Chem. Abst.*, 26: 339, January 20, 1932. All-glass apparatus for water distillation is described. Flask has constant-level device fused into bottom, into which hot water discharges from condenser. Product is sufficiently pure for experiments on phosphorescence, as it is free from metals.—*R. E. Thompson.*

**Copper Pipes for Water Conduction.** SCHACHT. *Pumpen-Brunnenbau*, 1930: 337-9; *Wasser u. Abwasser*, 27: 203. From *Chem. Abst.*, 26: 542, January 20, 1932. Though cost of copper pipe is higher, increased wear and freedom from corrosion make it more economical than iron pipe. There are no hygienic objections to its use.—*R. E. Thompson.*

**Two New Rustproofing Materials: Herolith and Tornosit.** J. G. DE VOOGD. *Het Gas*, 51: 319-21, 1931. From *Chem. Abst.*, 26: 411, January 20, 1932. Brief description of 2 new pipe-coating materials of Mannesmann Company. Tornosit, a benzene-soluble rubber compound, and Herolith, an alcohol-soluble artificial resin, are applied to pipe after removal of all scale with nitric acid and sodium hydroxide. Former is dried at atmospheric temperature and latter is baked on at 200°. Characteristics are discussed.—*R. E. Thompson.*

**Specific Conductivity of Drinking Water in Beograd.** PANTE S. TUTUNTZICH. Bull. soc. chim. roy. Yougoslav., 2: 77.92 (in German 92-5), 1931. From Chem. Abst., 26: 540, January 20, 1932. Determinations of specific conductivity of Beograd drinking water were made daily over period of several months and factor was calculated which indicates number of milligrams required to bring about change in specific conductivity of  $0.00001 \Omega^{-1}$ . This method permits precise, rapid determination of mineral content (average error is about 2 per cent) and control of water for industrial purposes.—R. E. Thompson.

**Standards for Mineral Spring Investigation (Evaluation).** L. FRESSENIUS. Z. wiss. Bäderkunde, 4: 668-71, 1930; Wasser u. Abwasser, 27: 197-8; cf. C. A., 24: 2817. From Chem. Abst., 26: 541, January 20, 1932. Physical and chemical methods are suggested such as WINKLER method for bromine; VON FELLEBERG method for iodine; NOLL-HAASE method for nitrate; BERGER method for nitrite; Prussian Geological Association apparatus for rare gases; and ENGLER-SIEVING apparatus for radioactivity.—R. E. Thompson.

**Removing Iron and Manganese (from Water).** PERMUTIT A.-G. Wasser u. Abwasser, 28: 298-9, 1931. From Chem. Abst., 26: 541, January 20, 1932. While ordinary waters can be freed from iron by simple aëration, those containing much organic matter in solution should be filtered, following treatment with potassium permanganate, hydrogen peroxide, or ozone. Addition of lime, or alum, is also sometimes effective in removing iron. A special manganese permutite is advocated for manganese removal.—R. E. Thompson.

**A Solar Water Purifier.** ACHILLE MARMO. Industria chimica, 6: 977-98, 1931. From Chem. Abst., 26: 541, January 20, 1932. Series of wooden tanks covered with glass was arranged to distil the water to be purified; sun was source of heat. It was found that bacteria such as *B. typhosum*, *B. coli*, *B. dysenteriae*, and *V. cholerae* are killed by combined effect of heat and action of ultra-violet rays of sun.—R. E. Thompson.

**Nitrate Determination in Drinking Water.** W. MULDER. Pharm. Weekblad 68: 995-7, 1931. From Chem. Abst., 26: 541, January 20, 1932. Method of SCHERINGA (C. A., 25: 1309) for colorimetric determination of nitrate in drinking water by means of sodium salicylate and sulfuric acid, followed by ammonium hydroxide, includes correction for presence of chloride, which diminishes color intensity. Correction factor is shown to be applicable only up to 2 milligrams chloride per 100 cc.; with from 2 to 10 milligrams, color intensity is constant at 80 per cent that of control. Modification is recommended consisting of adding at least 2 milligrams sodium chloride to both test and standard solutions. Use of factor is then unnecessary.—R. E. Thompson.

**Occurrence of Phosphine in Spring Water.** O. LONING and K. BRÜHM. Z. Untersuch. Lebensm., 61: 443-6, 1931. From Chem. Abst., 26: 541, January 20, 1932. Spring waters in diluvial sand of Bortfeld, W. Brunswick, in 1928 manifested a pronounced odor of phosphine. Silver nitrate test was positive. One water, which contained flocculent suspended matter, showed:  $P_2O_5$ , 6.9;

iron, 20; permanganate absorption, as high as 41 to 45 milligrams per liter; and carbonate hardness of from 28.3° to 42.6°. It is assumed that this unusual formation of phosphine was due to reduction of phosphorus compounds by organic matter which originated from juice of neighboring presses for ensilage of sugar-beet leaves.—*R. E. Thompson.*

**The Process of De-chlorinating Water by Means of Adsorption Charcoal.** FRIT. SIGMUND. *Z. Ver. deut. Ing.*, 75: 1280.2, 1931; cf. *C. A.*, 24: 3845; 25: 754. From *Chem. Abst.*, 26: 542, January 20, 1932. Chlorine water containing 62 p.p.m. free chlorine was run over samples of charcoal of different origins at velocity of 50 cc. per minute, periodic tests being made on influent and effluent for chloride ion, free chlorine, acidity, and alkalinity. With fresh charcoal, treated water first showed decreasing alkalinity and then increasing acidity. Chloride ion was fairly constant during alkaline period; during acid period it increased at first rapidly, then very slowly. Carbon especially treated to remove all alkalies gave an acid effluent, acidity soon becoming equivalent to chloride ion concentration. Chloride ion content increased, approaching 100 per cent of total chlorine in influent asymptotically. An interruption of process caused decrease in chloride ion content of effluent, which increased again in accordance with curve obtained before interruption. Reaction, which is shown to be monomolecular, is explained by author as reduction of hypochlorous acid adsorbed on surface of carbon. Fatiguing of carbon, according to author, is due to saturation of its surface with hydrochloric acid; thus treatment with alkali restores it. Results are not directly applicable to practical water purification processes where concentration of chlorine is far less than in these experiments. Criticism of the work by LINK is appended.—*R. E. Thompson.*

**Determination of Traces of Uranin in Water.** L. NYS. *Ann. soc. géol. belg.*, 54: B224-5, 1931. From *Chem. Abst.*, 26: 542, January 20, 1932. Reagent is required to destroy color due to uranin in one tube and comparison is made with untreated sample in similar tube. Of 180 substances experimented with, following were found best: butyric acid, valeric acid, caproic acid, esters of fatty acids, aniline, and essence of terebenthine. Uranin content of the order of  $8.10^{-9}$  gram/cc. was detected.—*R. E. Thompson.*

**Are Typhoid Bacteria Detectable in Well Water.** L. HARANGHI. *Zentr. ges. Hyg. Bakt. Immunitäts*, 22: 156, 1930; *Wasser u. Abwasser*, 27: 196. From *Chem. Abst.*, 26: 544, January 20, 1932. Of 18 wells under suspicion as infective foci of typhoid cases in Baja, only 1 gave positive results for typhoid group of bacteria. Conclusion: bacteriological examination of well waters for bacteria of typhoid group is not of great value in detecting sources of infection.—*R. E. Thompson.*

**Apparatus for Determining and Regulating the Content of Chlorine in Water to be Purified.** GEORG ORNSTEIN. *Fr.* 706,880, September 27, 1930. From *Chem. Abst.*, 26: 545, January 20, 1932.—*R. E. Thompson.*

**Sterilizing and Activating Materials.** GEORG A. KRAUSE. Ger. 532,989, July 6, 1927. From Chem. Abst., 26: 545, January 20, 1932. Materials, especially water, are sterilized and oligodynamically activated by bringing them into contact with oligodynamically active metals such as silver, copper, or alloys. Metal is distributed in fine state on porous carrier by heating such carrier soaked in gel of metal.—*R. E. Thompson.*

**Chemical Action of Aggressive Waters on Cement in Concrete.** J. O. ROOS. Pit and Quarry, 23: 41-52, 1931. From Chem. Abst., 26: 575, January 20, 1932. Constitution of portland cement and effect of percolating water in dissolving free calcium hydroxide and combined calcium oxide are discussed. Results are given of specific solvent actions of pure water and of those containing calcium as bicarbonate and aggressive carbon dioxide on different cements and mixtures. All cements, including alumina cement, have about same solubility in these waters. Carbonation of surface increases resistance of cement to water. Extraction of calcium oxide is reduced by admixture of acidic substances, or puzzuolanas containing reactive silica and silicates.—*R. E. Thompson.*

**Practical Apparatus for the Determination of Electrical Conductivity.** W. MUCHLINSKY. Chem. Fabrik, 1931: 462-3, 469-72. From Chem. Abst., 26: 628, February 10, 1932. Discussion of methods, with 13 cuts of instruments that may be constructed of simple materials to give rapid and accurate determinations.—*R. E. Thompson.*

**Colorimetric Method for Measuring the Hydrogen-Ion Concentration of Natural Waters.** DAPHNE GOULSTON. J. Proc. Roy. Soc. (N. S. Wales), 65: 37-9, 1931. From Chem. Abst., 26: 635, February 10, 1932. One-color indicator (*m*, or *p*-nitrophenol) is used, color being compared with standard buffer solution in colorimeter.—*R. E. Thompson.*

**The Amphoteric Nature of Aluminum Hydroxide.** ROBERT A. ROBINSON and HUBERT T. S. BRITTON. J. Chem. Soc., 1931: 2817-20. From Chem. Abst., 26: 640, February 10, 1932. Conductimetric titration of aluminum sulfate solution with sodium hydroxide reveals following steps:  $\text{Al}_2\text{O}_3 \cdot 3\text{SO}_4 \rightarrow \text{Al}_2\text{O}_3 \cdot 2.68\text{SO}_4$  (soluble)  $\rightarrow \text{Al}_2\text{O}_3 \cdot 0.6\text{SO}_4$  (insoluble)  $\rightarrow \text{Al}_2\text{O}_3 \cdot 0.12\text{SO}_4$  (maximum insolubility)  $\rightarrow \text{NaAlO}_2$ . Back titration with hydrochloric acid shows reactions to be reversible.—*R. E. Thompson.*

**Effect of Colloids and of Non-Aqueous Layers of Liquids on the Rate of Solution of Gases in Water.** L. A. KLYUCHAREV. J. Applied Chem. (U. S. S. R.), 4: 425-8, 1931. From Chem. Abst., 26: 641, February 10, 1932. A 0.1-millimeter layer of machine oil, or crude petroleum, on surface of water has practically no effect on rate of solution of carbon dioxide in water. Colloidal particles (arsenious sulfide, or ferric hydroxide) increase rate of solution, while butyric acid has reverse effect.—*R. E. Thompson.*

**Volumetric Method for the Microchemical Determination of Sulfates.** S. BALAKHOVSKII and F. GINSBURG. Z. anal. Chem., 86: 344-6, 1931. From

Chem. Abst., 26: 668, February 10, 1932. Precipitation of barium sulfate by barium chloride and titration of excess barium with potassium chromate in presence of bromothymol blue, phenol red, or cresol red, gives results accurate to 1.5 per cent on from 2 to 4 milligrams of sample. To avoid error caused by buffer solutions, evaporate sample almost to dryness and add from 0.3 to 6 cc. of alcohol to 1 cc. of sulfate solution.—*R. E. Thompson.*

**Colorimetric Estimation of Iron in Drinking and Waste Waters by Means of Sulfosalicylic Acid.** L. N. LAPIN and W. E. KILL. *Z. Hyg. Infektionskrankh.*, 112: 719-23, 1931. From Chem. Abst., 26: 789, February 10, 1932. Both ferrous and ferric ion can be determined by color reactions with sulfosalicylic acid.—*R. E. Thompson.*

**Correlation of Certain Soil Characteristics with Pipe Line Corrosion.** I. A. DENISON. *Bur. Standards J. Research*, 7: 631-42, 1931. From Chem. Abst., 26: 681, February 10, 1932. Corrosion occurring in group of Ohio pipe lines has been correlated with corrosiveness of certain soils. Most corrosive areas are occupied by heavy acid soils of glacial origin. Chief corrosion factors are acidity, texture, and drainage. Total acidity values and also pH values of soil extract with normal potassium chloride serve as satisfactory indicator of corrosiveness. Accelerated test, based upon corrosion of steel disk by moist soil, is described, results with which show general agreement with results of acidity tests.—*R. E. Thompson.*

**The Chemistry of Water Treatment.** DANA BURKS, Jr. *Refrigerating Eng.*, 22: 247-51, 1931. From Chem. Abst., 26: 789, February 10, 1932. Use of undistilled, or untreated, water for ice making may result in ice which is opaque in color and which on melting leaves sludge and insoluble residue of inorganic salts. Opacity of ice is due to salts which precipitate during freezing. By use of lime and alum, or sodium aluminate, it was possible to precipitate large proportions of calcium and magnesium salts and to remove sludge-forming materials. Sodium carbonate, or bicarbonate, was removed by preliminary treatment with magnesium zeolite and subsequent precipitation of magnesium with lime. When necessary, alkalinity was corrected by addition of acid or aluminum sulfate.—*R. E. Thompson.*

**The Rate of Solution of Oxygen in Water. VI. The Rate of Absorption of Oxygen by Sodium Sulfite Solutions.** SUSUMU MIYAMOTO and TETSUO KAYA. *Bull. Chem. Soc. Japan*, 6: 264-75, 1931; cf. *C. A.*, 25: 5074. From Chem. Abst., 26: 900, February 20, 1932. Rate of absorption of oxygen by stirred solution of sodium sulfite was followed by decrease in volume. Results agree with those previously obtained iodometrically. Rate is independent of concentration for range 0.35 to 0.75-normal, but decreases at higher and lower concentrations.—*R. E. Thompson.*

**Determination of the Radioactivity of Natural Waters and Some Results for Flowing Artesian Wells.** JAMES A. HOOTMAN. *Am. J. Sci.*, 22: 453-63, 1931. From Chem. Abst., 26: 910, February 20, 1932. Examination of 16 Mississippi

artesian wells showed from 0.00 to 0.688 millimicrocurie per liter. Methods of determination and calculation are described.—*R. E. Thompson.*

**An Oxidimetric Determination of Sodium.** H. GALL and K. H. HEINIG. *Z. anorg. allgem. Chem.*, 202: 154-60, 1931. From *Chem. Abst.*, 26: 937, February 20, 1932. Method depends on precipitation of sodium as  $\text{NaZn}(\text{UO}_2)_2(\text{AcO})_6 \cdot 6\text{H}_2\text{O}$ , dissolving precipitate in 5-normal sulfuric acid, reduction of  $\text{UO}_2^{++}$  with electrolytic cadmium, and titration of quadrivalent uranium with potassium permanganate. To 1 cc. of solution containing no more than 20 milligrams sodium chloride, add 10 cc. of filtered (KOLTHOFF and BARBER) reagent and allow half-hour for precipitate to form. Filter, wash with 20 to 30 cc. glacial acetic acid saturated with precipitate, and dissolve in 30 to 50 cc. 5-normal sulfuric acid. Dilute with water to make solution about normal in hydrogen ion and pass through 6-centimeter column of electrolytic cadmium. Filter to remove suspended cadmium and to insure atmospheric oxidation of a little trivalent uranium, and, finally, titrate with 0.1-normal potassium permanganate. In 14 analyses carried out with microbalance, greatest error was 0.08 milligram sodium, original sample of sodium chloride weighing 16 milligrams.—*R. E. Thompson.*

**Determination of Aluminum. Formation of Lithium Aluminate.** J. T. DOBBINS and J. P. SANDERS. *J. Am. Chem. Soc.*, 54: 178-80, 1932. From *Chem. Abst.*, 26: 936, February 20, 1932. To 100 cc. of solution containing about 0.1 gram aluminum, add few drops phenolphthalein indicator and slight excess of 10 per cent lithium chloride solution. Carefully add dilute ammonium hydroxide until very faint pink color is imparted to cold, stirred solution. After 5 minutes, filter and wash thoroughly. After ignition, precipitate has formula  $\text{Li}_4\text{Al}_{10}\text{O}_{17}$ . Precipitate is very bulky but washes easily.—*R. E. Thompson.*

**Soil Corrosion Studies. Nonferrous Metals and Alloys, Metallic Coatings, and Specially Prepared Ferrous Pipes Removed in 1930.** K. H. LOGAN. *Bur. Standards J. Research*, 7: 585-605, 1931; *Bur. Standards Research Paper No. 359*. From *Chem. Abst.*, 26: 950, February 20, 1932. Information concerning soils which has been obtained as result of Bureau's soil corrosion investigations makes it clear that rate of corrosion of any metal exposed to soil cannot be accurately expressed by single figure or group of figures. On account of variations found in all soils, influence of character of soil, differences in contact between soil and metal, changes in supply of oxygen and moisture, and effects of corrosion products, best that can be hoped for is expression representing average rate of loss of weight, or pitting, accompanied by figure for the standard deviation, probable error, or some other expression indicating how much the behaviour of any single specimen may be expected to differ from behaviour of average of representative group of specimens. Average values sufficiently accurate to show small differences in performance of competing materials can only be secured through testing of very large number of specimens.—*R. E. Thompson.*

**Under-Water Corrosion of Copper-Bearing Steels.** H. CASSEL and F. TÖDT. *Metallwirtschaft*, 10: 936-7, 1931. From Chem. Abst., 26: 950, February 20, 1932. Recent literature on behaviour of copper-bearing steel when completely immersed in water, which is somewhat contradictory, is discussed. Resistance to corrosion of copper-bearing steel is analagous to that of copper-plated steel. As copper layer is porous in both cases, it does not provide much resistance to corrosion, and addition of copper to steel for under-water use is purposeless. Three references included.—R. E. Thompson.

**Effect of Ultra-Violet Light on the Bacteria Content of Milk and Water.** L. VOGELER. *Milchwirtschaft Literaturber.*, 484-5, 1930; *Wasser u. Abwasser*, 28: 100, 1931. From Chem. Abst., 26: 1039, February 20, 1932. In clear water, there was reduction of 99 per cent. Complete sterilization of water containing large number of bacteria was impossible. Sterilization of milk was not feasible.—R. E. Thompson.

**Work of the Connecticut State Water Commission.** WILLIAM S. WISE. Atlantic City Meeting Am. Inst. Chem. Eng., December, 1931, Preprint, 15 pp. From Chem. Abst., 26: 1050, February 20, 1932. Satisfactory treatment of all industrial wastes in such manner as to yield profit to manufacturer is hopeless. He must clearly recognize his responsibility in protecting rights of public in State's waterways. Research work must form basis of making equitable decisions in allocation of streams to most economic uses. It has been found practicable to prevent large part of injury to streams which had previously been considered unavoidable. Researches on various types of wastes are discussed.—R. E. Thompson.

**The Effect of Storage of Distilled Water in Glass Ampoules on the Alkalinity and Total Solids Content.** A. P. MATTHEWS. *J. Am. Pharm. Assoc.*, 20: 767-70, 1931. From Chem. Abst., 26: 1064, February 20, 1932. Double-distilled water was placed in ampoules of Jena glass, sealed, and examined from time to time. Total solids increased in 18 months from 1.5 to 6.3 p.p.m. Of this, from 2.5 to 3.0 p.p.m. was organic matter, which did not increase. Increase in alkalinity was so slight as to be negligible. No glass splints or platelets appeared.—R. E. Thompson.

**Solvent Action of Water on Cement.** GRÜN. *Bauing.*, 11: 451-4, 1930; *Wasser u. Abwasser*, 27: 298, 1930. From Chem. Abst., 26: 1089, February 20, 1932. Relatively insoluble calcium silicate is hydrolyzed by action of large volume of water to silicic acid and calcium hydroxide. Best remedy is impermeability.—R. E. Thompson.

**The Measurement of Small Particles.** W. L. GADD. *Cement and Cement Manufacture*, 4: 763-7, 1931. From Chem. Abst., 26: 1159, March 10, 1932. Instrument called "obseurometer" is described. It operates on principle that opacity of liquid containing powder in suspension is function of number of particles.—R. E. Thompson.

**Tests of Integral and Surface Waterproofings for Concrete.** C. H. JUMPER. Bur. Standards J. Research, 7: 1147-77, 1931. From Chem. Abst., 26: 1410, March 10, 1932.—*R. E. Thompson.*

**Ueber das Absterben von Bakterien in unter Luftabschluss befindlichem Wasser und seine Bedeutung für die Wasserversorgung.** (On the Death of Bacteria in Water in Airless Reservoirs and Its Significance in Water Supplies.)

LEHMANN and REICHEL. Das Gas- u. Wasserfach, 76: 3, 41-44, 1933. Abstract in Neues Jahrb., 2: 4, 604, 1933. Water encountered far below the surface in openings in rocks such as joint cracks and solution cavities does not contain harmful bacteria because they are killed by the lack of oxygen.—*A. N. Sayre, courtesy David G. Thompson.*

### NEW BOOKS

**Der Kreislauf des Wassers auf unberührtem Hochmoor.** (The Circulation of Water on the Undisturbed High Moors.) PRYTZ. Ingeniørvidenskabelige skrifter A. 33. Kopenhagen; 128 pp., 1932. [In German]. Abstracts in Neues Jahrb., 2: 4, 603, 1933. Observations, on the nearly unbroken plains northwest of Aalborg, of flow, slope of plain, and ground water levels are explained and tabulated. Author concludes that ground water fluctuations are dependent on precipitation.—*A. N. Sayre, courtesy David G. Thompson.*

**Oklahoma Agricultural and Mechanical College. Engineering Expt. Station, Publication No. 22, 1934. Waterworks Conventions.** T. G. BANKS. 5, 6. Plea is made for waterworks conventions upon a higher plane. **Licensing of Water and Sewage Personnel.** H. J. DARCEY. 7-10. Discussion on requirements and operation of laws to this effect in N. J. and Texas. **Construction of Inexpensive Incubators for Water and Sewage Work.** J. T. GRIMSLEY. 10-13. An easily constructed, reliable and rugged incubator. **Studies in the Formation of Flocc by Aluminum Sulfate and Iron Coagulants.** EDWARD BARTOW. 15, 16. Cf. C. A., 27: 4327, 4607. **Water Treatment.** EDWARD BARTOW. 17-22. Excellent popular lecture. **Collection and Utilization of Gases from Imhoff Tanks.** C. H. RIGHTMIRE. 30-32. Method used at Enid, Oklahoma.—*O. M. Smith.*

**Methodiek voor Chemisch en Bacteriologisch Drinkwateronderzoek.** P. A. MEERBURG and A. MASSINK. 119 pp. P. Noordhoff N. V., Groningen-Batavia (1934). This work corresponds to our own Standard Methods of Water Analysis, except that it is not an official standard. It replaces the water section of the Codex Alimentarius, last published in 1914 and now out of print, and includes the procedures which the authors have found most suitable in their work at the Central Public Health Laboratory and the Imperial Water Control Bureau at Utrecht, Holland, of which they are in charge. The chemical methods do not differ essentially from those given in Standard Methods, except that qualitative as well as quantitative tests are listed for a number of substances. In several cases, two or more quantitative methods are given. Two schemes for bacteriological examination are given. The first uses the

ELJKMAN and McCONKEY tests for *B. coli*, the SCHARDINGER test, examination for streptococci, and total count. The second scheme, now used by the Water Control Bureau, makes use of modifications of the ELJKMAN and McCONKEY tests, the examination for streptococci, and total count and lists the most probable number of *B. coli*. In addition to these routine examinations, the authors give directions for determining aggressivity of the water toward calcium carbonate and metals, electrical conductivity, resistance to filtration, most suitable method for removal of iron and manganese, and chlorine consuming power. The book is a well-selected, well-printed compilation of current methods in water analysis, particularly those in vogue in Europe. The procedures given are stated concisely, but with sufficient detail. The emphasis on the relation between the sanitary survey and the laboratory findings, in the final section, is of practical significance. The timeliness of this work in bringing the 1914 methods up to date and the recognized standing of the authors make this an undoubtedly appreciated aid to Dutch water chemists and bacteriologists.—*Selma Gottlieb.*

**Annual Report of the Bureau of Sanitary Engineering, Maryland State Department of Health, 1933.** ABEL WOLMAN. 17 pp. Details are given of extensive activities of the Bureau, relating to water supply, sewage disposal, stream pollution, oyster surveys, etc. Typhoid fever death-rate in the state dropped to 2.2 per 100,000 in 1933, a new low record. Full advantage was taken of provisions of National Industrial Recovery Act and as a result sanitation work in the state will be advanced some 5 years. Studies of corrosion of distribution systems were continued. Break in force main leading from treatment plant at Annapolis resulted in disturbance of accumulated corrosion products of former years, causing many complaints. Tests indicated that non-aggressive water was now being produced and thorough flushing remedied the situation. Law creating the Water Resources Commission of Maryland and giving this body jurisdiction over the waters of the state became effective on January 1, 1934. Studies pertaining to proposed low-flow stream control of Potomac River indicated Savage River as most desirable location for impounded storage. Examinations of water supplies and studies of assimilative capacities of water courses were made in connection with proposed sites for distilleries. No practical method is at present available for complete treatment of distillery waste. Tabulations are appended showing activities of the Bureau and typhoid death-rate for a number of years past.—*R. E. Thompson.*

**Reinforced Concrete Reservoirs and Tanks.** W. S. GRAY. London: Concrete Publications, Ltd. 200 pp. 10s. Reviewed in Cong. Rec. and Eng. Rev., 46: 752, June 29, 1932.—*R. E. Thompson.*

**Hydraulics of Open Channels.** BORIS A. BAKHMETEFF. Cloth: 6 x 9 inches: pp. 329. McGraw-Hill Book Co., New York and London. \$4. Reviewed in Eng. News-Rec., 109: 84, July 21, 1932.—*R. E. Thompson.*

**Water Purification Control.** EDWARD S. HOPKINS. Cloth: 5 x 8 inches: pp. 131. Baltimore: Williams & Wilkins Co. Reviewed in Eng. News-Rec., 109: 202, August 18, 1932.—*R. E. Thompson.*

**Principles of Public Utilities.** ELIOT JONES and TRUMAN C. BIGHAM. Cloth: 6 x 9 in.: pp. 799. New York; Macmillan Co. \$6. Reviewed in *Eng. News-Rec.*, 109: 324, September 15, 1932.—*R. E. Thompson.*

**Pumping Machinery. Part I—Historical Notes.** G. F. WESTCOTT. Paper: 6 x 9 in.: pp. 103. H. M. Stationery Office, London. 2s 6d. Reviewed in *Eng. News-Rec.*, 109: 756, December 22, 1932.—*R. E. Thompson.*

**Sanitation of Water Supplies.** MURRAY P. HORWOOD. Cloth: 6 x 9 in.: pp. 181. Springfield, Ill., and Baltimore, Md.; Charles C. Thomas. \$3. Reviewed in *Eng. News-Rec.*, 110: 92, January 19, 1933.—*R. E. Thompson.*

**Water Analysis for Sanitary Purposes.** E. FRANKLAND. 2nd edition. London: Gurney and Jackson. 144 pp. 5s. From *Chem. Abst.*, 26: 4399, August 20, 1932.—*R. E. Thompson.*

**Encyclopedia of Oxy-Acetylene Welding. Vol. I. Pipe Construction.** Issued by International Advisory Committee for Carbide and Welding Technique. London: The Acetylene and Welding Consulting Bureau, Ltd. From *Chem. Abst.*, 26: 4787, September 20, 1932.—*R. E. Thompson.*

**Die chemische Untersuchung von Wasser und Abwasser.** JOSEF TILLMANS. 2nd edition. Halle: W. Knapp. 252 pp. M. 17.50; bound, M. 19. From *Chem. Abst.*, 26: 5164, October 10, 1932.—*R. E. Thompson.*

**Distributions d'eau.** G. DARIÈS. 2nd edition, revised by B. SAINT-PAUL. Paris: Dunod. 1078 pp. F. 132; bound, F. 141. From *Chem. Abst.*, 26: 5365, October 20, 1932.—*R. E. Thompson.*

**Quelques documents sur la verdunisation des eaux, rassembles pour la troisième exposition internationale de technique sanitaire et d'hygiène urbaine à Lyon.** PHILIPPE BUNAU-VARILLA. Paris: J.-B. Baillière et fils. 50 pp. From *Chem. Abst.*, 27: 793, February 20, 1933.—*R. E. Thompson.*

**Hydrochemische Methoden in der Limnologie, mit bes. Berücks. d. Verfahren von L. W. Winkler.** Rezső Maucha. Bd. XII of *Die Binnengewässer*. Stuttgart: Schweizerbart. 173 pp. Linen, M. 19.50. From *Chem. Abst.*, 27: 1072, March 10, 1933.—*R. E. Thompson.*

**Die Fehlerquellen der Clark'schen Methode zur Bestimmung der Härte eines Trinkwassers und ihre Brauchbarkeit im Vergleich zu einigen anderen Härtebestimmungsmethoden nebst einem Bericht über die derzeitigen Auffassungen von der Bedeutung der Härte für den Gesundheitszustand des Menschen.** WILHELM GILGES. Thesis, Bonn, 1931. 44 pp. From *Chem. Abst.*, 27: 1433, March 20, 1933.—*R. E. Thompson.*